HIGH TECHNOLOGY BUSINESS

JUNE 1988

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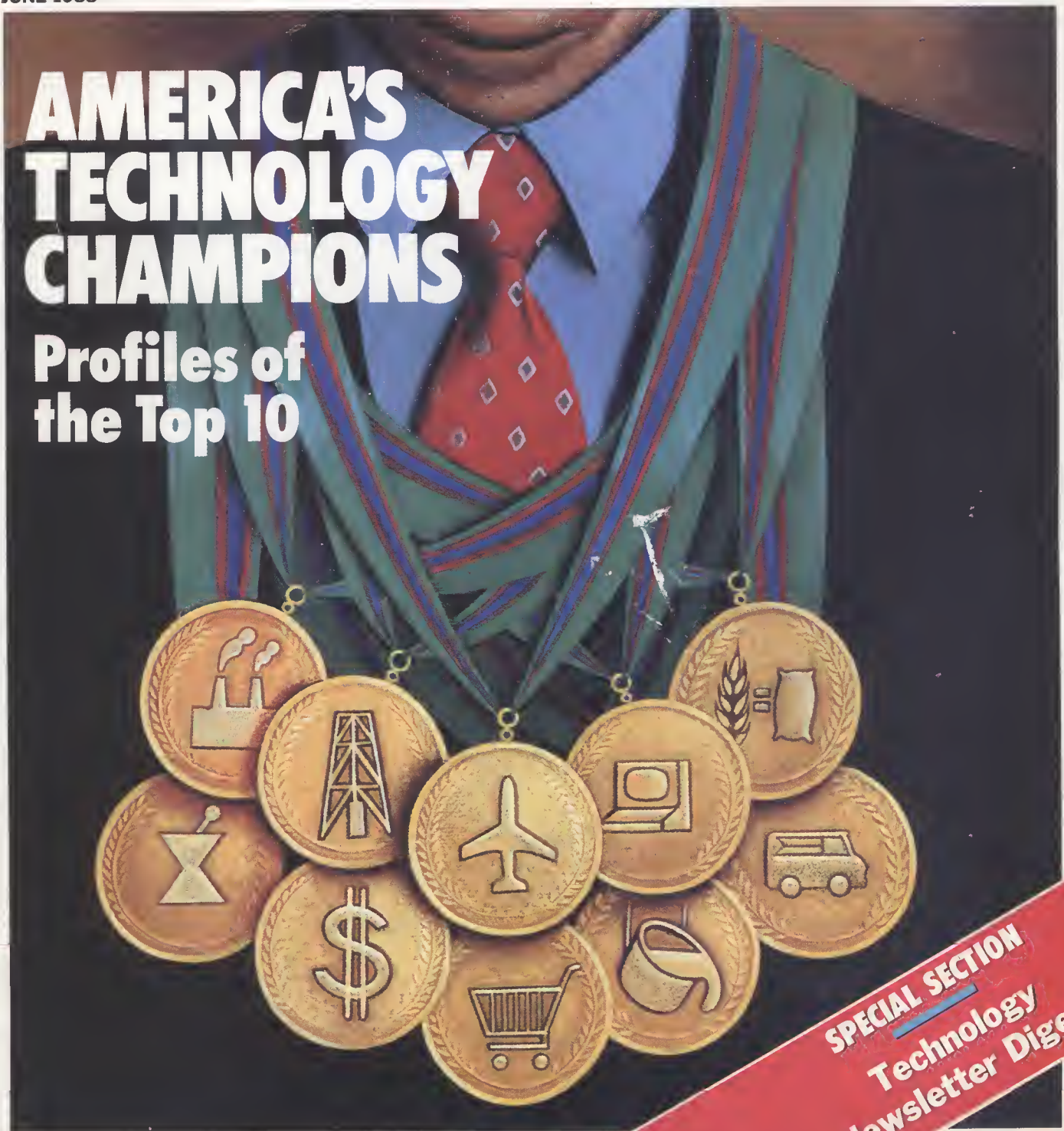

AMERICA'S TECHNOLOGY CHAMPIONS

Profiles of the Top 10

SPECIAL SECTION
Technology Newsletter Digest

Planned obsolescence is an unfortunate reality with many of today's business phone systems. Some manufacturers won't let you upgrade to a better system without first replacing most of your equipment.

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JUNE 1988 VOL. 8, NO. 6

HIGH TECHNOLOGY BUSINESS

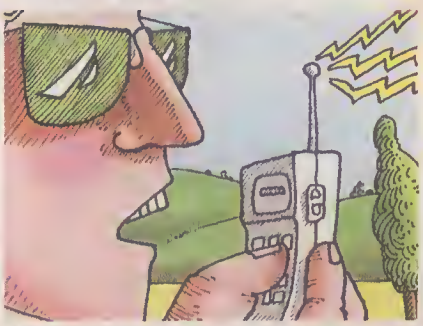
FEATURES

COLUMNS

MARKETWATCH

DEPARTMENTS

How the best harness high-tech's power, p. 22.



What's in store for portable phones, p. 42.

Who's winning big in on-line lottery systems, p. 47.

Cover illustration by Roy Pendleton

New equipment using the latest technology in an easy-to-operate system will be provided by a new air traffic control system for the Federal Aviation Administration (FAA). In competition to develop the Advanced Automation System (AAS), Hughes Aircraft Company's version will include controller displays, advanced computers, communications networks, and software that can handle many tasks now completed manually. This dynamic new system will make possible direct, fuel-efficient flights, more efficient use of runways and airport "landing slots," fewer delays, and a safer overall system. To meet FAA requirements, the AAS is being designed for a downtime of less than three seconds per year.

Carried aboard a new satellite, positioned to detect storms threatening the East Coast, are two experiments. The Geostationary Operational Environmental Satellite (GOES) H, designed and built by Hughes for the National Oceanic and Atmospheric Administration, includes a space environment monitor (SEM) and an experimental receiver. The SEM assesses magnetic field strength and direction, solar x-ray fluctuations, and particles in its vicinity that make up solar wind and radiation belts around the Earth. The receiver will be used to aid in international search and rescue missions by monitoring radio distress signals from troubled ships or aircraft throughout most of North and South America. GOES H is in geosynchronous orbit above the Atlantic seaboard.

A single high-power microwave system will distribute 60 television channels in the San Francisco Bay area from one centrally located headend site. The 60-channel AML® high-power array, built by Hughes, will allow United Cable Television Company to interconnect San Francisco's East Bay, South Bay, and Peninsula areas. By using Hughes' AML microwave link, six communities will be served without the expense of hardline transportation trunks or duplicating headend equipment and building facilities. United will also cut operating costs by maintaining only one headend instead of six.

A new inspection tool can locate breaks and imperfections in optical fibers and visually inspect the continuity of individual fibers. The Hughes Glocater™ fiber-optic fault locator consists of an "enhanced" helium-neon laser, high-efficiency fiber coupler, and power supply. Designed for use during installation, re-arrangement, maintenance, and other procedures, the locator is attached to fibers being tested. In addition to its use in system acceptance testing of cables, jumpers and pigtails, the Glocater can serve as a tool for fiber-optic training centers. It can also be used on both single-mode or multimode fiber of any wavelength to verify continuity and provide positive end-to-end identification.

Hughes Ground Systems Group is applying its airspace management experience to the exciting challenges of worldwide air traffic control. These systems will be designed to ensure service 24 hours a day, 7 days a week. They will support distribution of processing among multiple computers linked via local area networks. The many challenges include design and development of hardware and software to support advanced display and man-machine interface technology, and using satellite technologies for future ATC applications. To help design the next generation of air traffic control systems, send your resume to Hughes Ground Systems Group, Employment Dept. S2, P.O. Box 4275, Fullerton, CA 92634. Equal opportunity employer. U.S. citizenship required.

For more information write to: P.O. Box 45068, Los Angeles, CA 90045-0068

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In North Carolina, Our Work Ethic Isn't Confined To The Workplace.

In North Carolina we don't take terms like "work ethic" lightly. Here work ethic is a way of life, an attitude.

An attitude that starts with free public kindergarten and goes all the way to some of the finest research facilities in the world. An attitude of learning *and* doing, in some of the most prestigious universities and most advanced technical schools in the nation.

But productivity may be the best reason to take a closer look at North Carolina's workers. Our workers produce $.12 more per $1 earned in wages than the nation's other workers in the same industries. And more productivity from your work force, means more profit for your company.

North Carolina workers have an almost unique opportunity for training and skill development through the state's extensive education programs. There are 58 technical and community colleges in the state making it the third largest such system in the country. In fact, 1 out of every 7 North Carolina adults is enrolled in a community or technical college and no matter where you live in the state, you're within a 30 minute drive to one of these institutions.

The state's exemplary public and private universities and colleges are providing industries with scientists, engineers, doctors, and teachers. People with the skills to work for industry and the education to advance it. (North Carolina schools are happy to work with incoming companies to design programs for their specific requirements.) We think you'll agree that North Carolina has one of the hardest working work forces in the nation.

To learn more about putting North Carolina to work for you, contact Robert G. Brinkley, Assistant Director-Business/Industry Development Division, North Carolina Department of Commerce, 430 North Salisbury Street, Raleigh, NC 27603, phone (919)733-4151.

We're ready to go to work, for you.

NORTH CAROLINA

The Better Business Climate

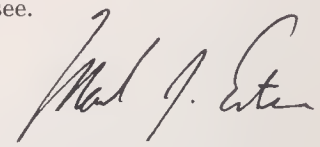
The Newsletter Connection

IT IS ONE OF the ironies of high technology that some of the best, most comprehensive, and in-depth discussions of key issues in the field reach only a very small number of people—even though the wider dissemination of the material could be of substantial benefit to anyone whose personal or business life could be affected by the discussions.

The reason: this excellent information is contained in newsletters that cover individual industries in considerable depth but do not reach beyond their particular areas of expertise. These small-circulation publications command premium prices because their information is of premium quality. However, they do little or no advertising, are targeted only at readers within the specific areas that they cover, and can be very difficult for people in other areas to learn about, much less track down.

We have tracked these newsletters down for our readers, because HIGH TECHNOLOGY BUSINESS is committed to bringing you the highest quality, most useful information you can get anywhere—across the entire spectrum of high-technology businesses. Starting with this issue, we have added a regular monthly section called *Newsletter Digest,* in which we highlight the best, most bottom-line-oriented information from dozens of the most respected high-technology newsletters throughout the United States. *Newsletter Digest* begins on page 57.

This new section, combined with our exclusive survey of which U.S. businesses make the best use of technology (p. 22), a look at the prospects for medical scanners (p. 37), and information on the mobile-phone revolution and ways you can use it to bring your company greater profits (p. 42), makes this month's HIGH TECHNOLOGY BUSINESS even more laden with information than usual. Consider this the start of a trend. You, our readers, have consistently told us in surveys in the last few months that what you most want is clear, solid information with a strong business focus. In response to your requests, that is just what we are providing this month, and what we will continue to provide through additional new monthly features and even more of the sort of content that you have told us you want to see.



Mark J. Estren

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HIGH TECHNOLOGY
BUSINESS

The Biotech Outlook

CONTRARY TO your April cover story, "Cash Crisis Creates Biotech Alliances," my company has never canceled an initial public stock offering. ZymoGenetics has never registered an IPO statement and had no plans to go public when the market crashed last October. I was equally dismayed to see ZymoGenetics listed under the sensationalist heading "Five on the Ropes." This is certainly not the case; we continue to discuss technology licensing and joint-development programs with potential corporate partners, as we had been doing before the crash.

The article's subhead stating that "... many companies are trading independence for financing" is perplexing, given that most biotech companies have evolved based on strategic alliances with larger pharmaceutical companies. While smaller companies perhaps hoped to achieve greater financial independence through public equity offerings, the stock-market crash has merely postponed these aspirations. Alliances and agreements continue to provide a viable avenue to longer-term prosperity, and the situation is not nearly as bleak as your article suggests.

David L. Graham
Director of Corporate Development
ZymoGenetics
Seattle, Washington

Editor's note: *The "On the Ropes" box in our April cover story referred both to companies that had filed formal public offerings and to companies that, in the opinion of financial analysts, had serious internal discussions about filing public offerings. Those internal discussions were confirmed by executives at the companies in question.*

Smart Houses: Expensive Toys

I READ WITH great interest the March article on automated houses ("Companies Struggle to Automate Homes"). In my opinion, the Smart House concept promoted by the National Association of Home Builders (NAHB) will never catch on. The primary stumbling block to this concept is resistance to change within the electrical-contracting business. The NAHB boasts some major players in its program, but I fear that most of these firms joined simply as a precaution in case the technology does catch on.

I have seen a system installed by Hypertek. The system is interesting and the people at Hypertek believe in it, but it is nothing more than a microprocessor-based time clock. I'm not so sure I need my washing machine and television set to be able to communicate with my coffee pot, or need the ability to call my home computer from the car to turn on the outside lights before I get home. A plug-in time clock that costs $20 solves that problem.

As the article mentioned, another stumbling block is the need for a common language so all this equipment can interact. This problem has plagued General Motors in attempting to develop its MAP (Manufacturing Automation Protocol) system. Severe problems exist because companies such as IBM want to develop a de facto standard and resent a manufacturer trying to call the shots. I can't see the NAHB, which has far less clout than GM, developing a unified communications protocol.

The Smart House and all other home-automation systems remain a technological curiosity and will not be out of the developmental phase for a long time, if ever. They are doomed to remain expensive toys.

Robert A. Germinsky
Managing Editor
CEE
White Plains, New York

Different Source, Same Result

THE FEBRUARY article "Biotech Targets Fight Back" was concise and informative, but it implies that the only human insulin on the U.S. market is Humulin, developed by Genentech and marketed by Lilly. In 1983, Squibb-Novo's semisynthetic human insulin Novolin was released in the United States. Although Humulin is produced from *E. coli* using recombinant DNA and Novolin is produced from purified pig insulin using transanimation, the end results are indistinguishable from purified insulin from the human pancreas.

Rex S. Clements, Jr., M.D.
Vice President, Medical Affairs
Squibb-Novo Inc.
Princeton, New Jersey

Resolution Roadblocks

IN HIS MARCH computer column, "Looking Good on Paper," Andrew Seybold states that the VGA display "provides resolution as sharp as 640×300 dots per inch." Much of his article is based on the assertion that this resolution is sharper than the 300×300 resolution offered by most laser printers.

The maximum resolution of the VGA in graphics mode (with the exception of the 8514) is indeed 640×480; however, this is the total number of "dots" that can be individually controlled by the display system on the entire screen. The graphics resolution is thus about 64 dots per inch on an average 10-inch screen—much lower than the 300 dots per inch of typical laser printers.

Most of the commercially printed material we see is produced by photo-typesetting and does not appear to be made up of individual dots, as does laser printing. In order for laser-printer output to look as good, the resolution must be about 1,000 dots per inch or greater. The obstacles to producing such a device include the fact that storing 8×10 inches (a single page with margins) of 1,000-dot-per-inch graphics requires 10 million bytes (characters) of memory.

Leonard G. Lehew
Vice President
Lehew-Tyler Inc.
Myrtle Beach, South Carolina

In our March article "Fax Makers Target Low-End Market," a note in the box describing the 1987 U.S. market for facsimile machines incorrectly stated that Pitney Bowes fax machines are made by Ricoh Corp. In fact, Pitney Bowes fax systems are built by Matsushita.

We welcome comments from our readers. Address letters to Editor, HIGH TECHNOLOGY BUSINESS, 214 Lewis Wharf, Boston, MA 02110. We reserve the right to edit letters for length and clarity.

New Developments

Issues, products and advances that help create new opportunities for high-tech businesses

- Scratch-proof coating protects almost everything
- Special sunglasses mimic natural protection
- Teleconferencing takes on mass appeal

'Smart' Container Monitors Medication

AN ELECTRONIC cap for drug containers should help pharmaceutical companies monitor their clinical trials and may eventually help people keep track of their daily medication.

Drug companies spend years testing new medications before requesting Food & Drug Administration approval to market them. Such trials involve as many as 600,000 volunteers each year, and companies must know whether the volunteers are taking their medication on schedule to determine the effects of the drug being tested.

Late last year, Aprex Corp. of Palo Alto, Calif., introduced an electronic cap that fits over a standard drug vial. The cap records the time and date each time the vial is opened. When patients have taken all the medication, they return the caps to the testing company, which sends them to Aprex. A port on the cap connects to a personal computer, and Aprex uses the data to compile a report on how often the patient took the drug.

Aprex charges companies $73 a report and sells the reusable caps for $29 each. Complete clinical trials cost $1,500 to $3,000 per patient. The company has sold more than 1,200 of the patented caps since September 1987, but won't be able to evaluate the program until more patients return their caps.

Electronic cap tracks drug tests.

APREX CORPORATION

If the clinical-trial program proves successful, Aprex plans to sell the system for general use with prescription drugs dispensed through pharmacies.

Cable Radio With Digital Sound

DIGITAL AUDIO has spoiled a lot of music lovers; once treated to the flawless sound of compact discs, they find it grating to listen to anything else. Two companies hope to cash in on this addiction by launching cable-radio systems that enter homes through the same cable that now delivers television shows. Both systems will provide the superb high fidelity of digital sound offered by compact discs and digital audio tape.

When the systems become available later this year, subscribers will buy an adapter to decode the digital signals and pay a monthly fee to the cable company. "It's the audio equivalent of Home Box Office," says Tom Oliver, president of International Cablecasting Technologies (ICT) in New York.

ICT and a competitor—Digital Radio Labs of Lomita, Calif.—will sell the equipment and receive a percentage of the subscription fees. Almost 45 million households in the United States have cable; if the services can penetrate 10 percent of that market, they could generate more than $100 million in revenues.

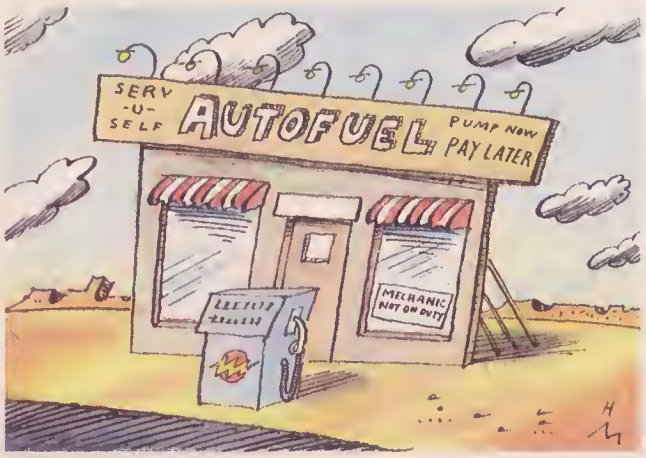
ICT plans to offer 10 channels; eight will carry commercial-free music in a format similar to the format of conventional radio stations. A ninth channel will deliver album sides on demand, and the last channel will transmit digital data.

The Digital Radio Labs system will have 16 channels, and president Norman Hogarth says its sound will equal the crystalline quality produced by compact discs. However, compact discs use 16 bits to encode each instant of sound; to squeeze in the extra channels, the cable system must use fewer than 16 bits for that task.

Put a Sensor In Your Tank

ELECTRONIC sensors are helping rental-car companies process their cars, and may soon lead to chains of automated gas stations. The Autofuel system uses such sensors to gather information about cars and send it to a computer. Resource Network International of New York is marketing the system for Israel's Tadiran Ltd., which originally developed it for internal use.

At Chicago's O'Hare airport, Budget Rent-a-Car has installed Autofuel sensor coils in its cars' rear bumpers. When renters return a car, they drive over another coil embedded in the ground that records the car's identification number, odometer reading, fuel level, and the time and date. The system transmits the information to the rental-office computer, which calculates charges and prints a contract, often before the renter finishes parking the car.



HAL MAYFORTH

The base system costs $8,000 to $10,000, plus about $200 per vehicle. Budget plans to have the system in all its corporate locations by the end of the year.

Aiming at a bigger market, Resource Network International hopes to apply its system to self-service gas stations. The company would like to make such stations the automatic teller machines of the oil industry. "AutoFuel will become what 24-hour-banking is today," predicts Marty Goldstein, vice president of marketing and finance. He envisions thousands of unmanned gas stations that eliminate the need for cash or charge-card authorizations.

To use such a station, a car would need a sensing coil at the gas cap. The gas-pump nozzle would contain a receiving coil connected to a control unit inside the station. When the driver stuck the nozzle in the tank, the car would send its identification number, fleet identification, authorized grade of fuel, odometer reading, and the time and date to the control unit. The data would travel to the oil company's computer system for automatic charging to the customer.

Workstations Direct Air Traffic

THE DEPARTMENT of Transportation is building a $10-million workstation-based system to manage air traffic, designed to improve safety and cut delays.

The system, created by the department's Transportation System Center in Cambridge, Mass., uses software from Unisys and Input Output Computer Services. The workstations come from Apollo Computer. AT&T and GTE SpaceNet will provide ground and satellite communications.

According to the Transportation System Center (TSC), the workstation system costs 80 percent less than an equivalent mainframe system and displays all flights, updates images every six seconds, and gives information on flights due to arrive in the next eight hours. On the old mainframe-based system, controllers had to consult tables for flights still outside their region.

The system is now working at control centers in Los Angeles, Cambridge, and Washington. The other 17 U.S. control centers should have it by 1992.

Airlines, the military, and foreign countries have shown interest in the system. One airline executive told the TSC the system could save his company $100,000 a day.

Whither the Weather?

TECHNOLOGY IS playing an increasing role in helping predict the weather, both in huge government systems and in small services designed for businesses and individuals.

On the high end, Unisys of McLean, Va., has developed Nexrad, a radar system for the National Oceanic & Atmospheric Administration. This $450-million system uses Doppler radar to peek inside thermal masses in the atmosphere.

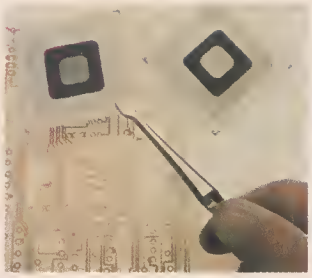
On the lower end, Meta-Comet Software of Hartford, Conn., is marketing its Accu-Weather Forecaster, which lets users tap into the Accu-Weather Inc. database. This database compiles data from the National Weather Service and other sources, which users manipulate on a personal computer to create their own forecasts. The $89.95 service and software package is aimed at transportation and insurance companies, pilots, farmers, and fire departments.


CLAY DEBEVOISE

Accu-Weather Forecaster helps businesses make their own predictions.

Opportunities in Coatings

SCRATCH-PROOF windshields and complex alloys will be just two results of a new coating process called low-temperature arc vapor deposition. The process deposits practically any metal, alloy, ceramic, or semiconducting coating onto paper, cloth, plastics, glass, ceramics, metals, and other materials. "If you can squeeze electricity through it, we can coat with it," says David Mager, executive vice president of sales and marketing for Vapor Technologies of Mount Vernon, N.Y.



New process coats nearly anything.

VAPOR TECHNOLOGIES INC.

The company hopes to use the technique to put ceramic and metal coatings on plastic engine and machine parts, and also to coat fibrous materials such as cloth and paper with nickel to produce high-power, lightweight batteries. The process could also produce commercial quantities of alloys in which the boiling point of one material is lower than the melting point of the other; using current alloy techniques, one material vaporizes before the other melts.

The patented process, developed by Vapor Technologies' Eduard Pinkhasov, transforms a coating material from a solid to a liquid and then deposits it on an object. The process applies coatings uniformly in almost any thickness over very large areas at room temperature or under high heat.

Vapor Technologies has developed more than 2,000 prototype products with the process, including printed-circuit boards and lightweight materials for the aerospace industry. The company, which was founded in January, wants to license the technology to other companies.

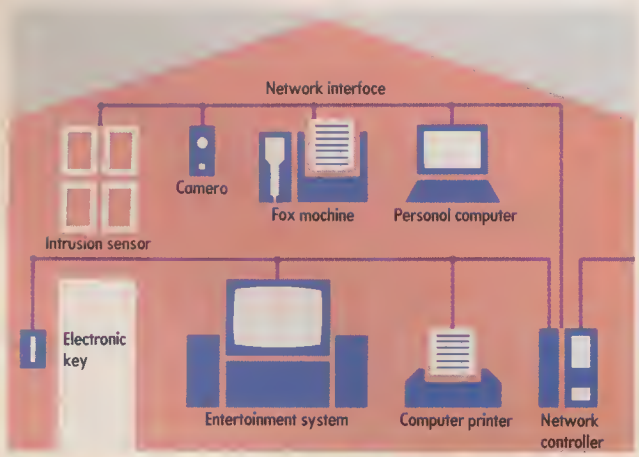
Look Ma, No Wires

A VARIETY OF electronic products now use AC power lines instead of dedicated wires to send music to speakers, information to computers, and conversations to telephones.

One such product, the Spectrum AC system from NEC Home Electronics, will use NEC's Home Bus data-communications standard to send data over power lines between computers and peripheral devices, security systems, audio/video systems, and household appliances. The system transmits information eight times faster than most personal-computer modems and uses a variety of frequencies to eliminate noise and interference. NEC has not yet set an introduction date or prices, but director of new-product development Philip Rittmueller says the Japanese company is testing the system on U.S. power lines.

Other devices, the Model 4250 and 4275 telephone sets from GTE, use FM multiplexing to send voice traffic over the electrical wires, acting as two-line key systems. The sets let users manipulate calls as in a professional telephone system without the expense or hassle of a control unit, special wiring, or professional installation. Even though the systems plug into standard wall jacks, callers don't need an outside line to reach any of five other extensions. The phones were introduced early this year at prices ranging from $180 to $220 each.

Recoton Corp. of Long Island City, N.Y., uses similar technology in its W-100 speakers. Earlier wireless speakers used infrared signals, and thus required an uninterrupted line of sight between the transmitter and the speaker. The company introduced its $270 system late last year and claims that it sounds as good as similarly priced speakers that connect to stereo equipment via standard speaker wire.



ELIOT BERGMAN INC.

NEC's Spectrum AC will link computers and appliances through power lines.

Teleconferencing For the Masses

A NEW TYPE of teleconferencing lets individuals join lectures, press conferences, or other events by phone. Instead of connecting three or four business associates, mass teleconferences let large groups of strangers listen in or talk to each other.

For example, some pharmaceutical companies use teleconferencing to present seminars for doctors, who can call in from anywhere in the country.

Teleconversant Ltd. of Cambridge, Mass., offers local programs to groups ranging from first-time mothers to gay-rights activists. Teleconversant charges callers $6 per hour to listen to a program.

American Teleconferencing Services Ltd. of Kansas City, Mo., provides a similar service to radio stations via satellite. Reporters can dial in to press conferences with sports figures and tape the event to cull direct quotes for broadcasts.

Perhaps the best-known teleconferencing services are the talk lines that have sprung up in major cities across the country. These services connect up to 10 callers at once; a moderator keeps the conversation flowing. On Long Island, for example, New York Telephone began gearing its teleconferencing technology to consumers late last fall, with a Santa line for children and others for teens and adults. Such services are popular, but their future is clouded by controversy over high costs and "phone sex" services.

Sunglasses Tinted With Skin Pigment

BY THIS TIME next year, a new kind of sunglass lens will use a version of melanin—the protective pigment the body releases when exposed to the sun—to ward off rays that can cause skin cancer and cataracts.

The lenses, standard plastic coated with a thin layer of synthetic melanin, were created by James Galas, president of Gal-Tech Inc. of San Antonio and assistant professor of physics at the University of Texas at San Antonio. Galas says the Melanite lenses protect eyes by absorbing and scattering all the light frequencies the sun emits, not just the ultraviolet rays that most sunglasses repel. Melanite simulates natural protection from all parts of the light spectrum.

Galas says the lenses will be especially useful for people over 40; by that age, most people have lost a third of the melanin production in their eyes.

Galas is seeking a marketing partner for the amber-colored lenses. He expects finished versions of the glasses to cost $100 to $150, about the same as conventional top-of-the-line fashion sunglasses. Galas says the coating process could also be used in car windshields and contact lenses.

Survey: Progress Won't Cut Jobs

A MAJORITY of U.S. decision-makers believe that technological advancement will not eliminate jobs, at least not this year.

In an exclusive HIGH TECHNOLOGY BUSINESS survey of 988 business decision-makers, 58 percent of the respondents say they do not anticipate technology-related job cuts in 1988. Just 14 percent say they think jobs will be lost to technology; 28 percent have no opinion. As for technology creating jobs, the respondents are about evenly split.

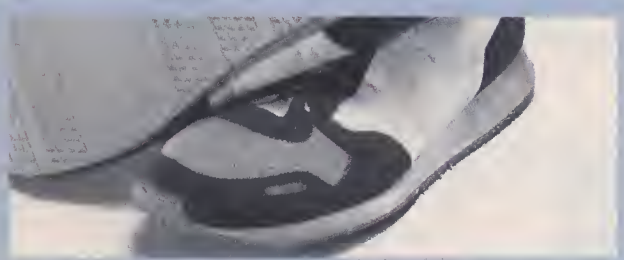
Though somewhat encouraging, these results are less optimistic compared to the 89 percent of respondents who view technological change as a positive factor in business management (see "Executives Bullish on Technology," May 1988, p. 10).

Surprisingly, among those respondents who view technology's effects as negative, a substantial 34 percent say that technology will lead to job cuts this year. Still, 49 percent of the pessimists are confident that high technology won't mean staff reductions, and the rest had no response.

The 41 percent of respondents who think technology will create jobs this year are slightly outnumbered by the 43 percent who think it won't, with the rest offering no opinion. Surprisingly, when counting only those who say that technology is good for U.S. business, a relatively constant 43 percent say technology will create new jobs, while 42 percent say it won't. Among technology negativists, only 29 percent say advances will create jobs this year, and 46 percent see no new jobs.

HTI Custom Research conducted the survey for HIGH TECHNOLOGY BUSINESS.

ALSO WORTH NOTING



ALPHAFLEX INDUSTRIES

Advanced additive strengthens rubber and plastic, reduces friction.

■ Alphaflex, a patented rubber additive, may soon be used to strengthen items from tennis shoes to military tank treads. Other possibilities include wiper blades, gaskets, O-rings, and silicone products. Alphaflex Industries of Indianapolis makes two forms of the additive; one doubles the tear strength of some rubber compounds and the other provides slickness and reduces friction. The company has begun building a plant to produce three million pounds of Alphaflex per year.

■ A monitor that watches over gears should help prevent accidents and product damage. The G-3000 vibration analyzer from Monitoring Technology of Falls Church, Va., locates faults in situations where traditional vibration analysis doesn't work. Eaton uses the system to test its supercharged engines and GM uses it to check transmissions. The device could work on aircraft-engine gear drives, ore-processing equipment, and machinery in nuclear power plants. It costs $30,000 to $100,000.

■ Political aficionados can follow the action electronically using an on-line database from Dialcom Inc. and the American Political Network. This database accepts information from contributors in business, the media, politics, and government concerning campaign developments, schedules, and polls, plus insider analysis and commentaries. Dialcom subscribers pay $65 per hour to connect to the on-line service.

■ Planners of big events may soon be able to tap computer power to adjust seating arrangements in arenas and concert halls. A system from Mitsubishi Heavy Metal Industries Ltd. of Tokyo handles as many as six configurations. Now being installed in the 11,000-seat SHIN-Yokohama Event Hall in Tokyo, the system will be able to completely rearrange the floor plan in 3½ hours.

■ Stanford University engineering students have created a mechanical hand to ease conversation for the 15,000 deaf-blind Americans who generally depend on tactile fingerspelling. The hand, dubbed Dexter, is a cooperative project of rehabilitation researcher David Jaffe of the Palo Alto Veterans Administration Medical Center and Deborah Gilden of the Smith-Kettlewell Eye Research Foundation. A message typed into a microcomputer activates Dexter's fingers, which move by air-compression valves and spring-driven cables.

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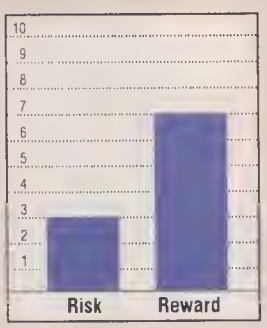

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1. 1987 Revenue	$2.4 B
2. Estimated 1988 Revenue	$2.5 B
3. Earnings Per Share:	
last quarter	$.29
last fiscal year	$.55
4. Estimated Earnings Per Share:	
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next fiscal year	$1.90
5. Recent Stock Price	$30
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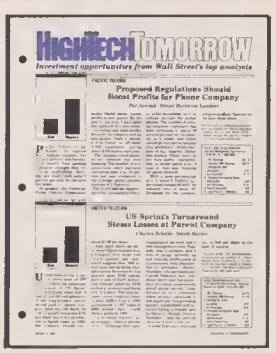

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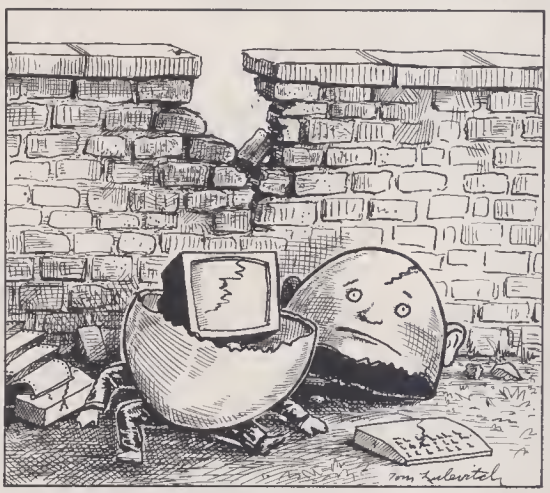
Caution: Slow Growth Ahead

INDUSTRY'S MAJOR PROBLEMS PREDATE THE CRASH

■ **By Donald C. Bellomy**

FOR A WHILE, the economic impact of last October's Wall Street debacle on the computer industry looked like the political fallout of Pat Robertson's strong showing in the Iowa caucuses: lots of sound and fury, then blissful apathy when nothing seemed to come of it. But the crash is putting additional pressure on a computer industry already facing serious challenges at the top end of the market.

The first indication of the crash's effects came late in the first quarter of 1988, when a number of top computer companies, including Wang and Prime, began quietly telling analysts that they might not be able to meet their revenue forecasts. These companies blamed "lengthened U.S. sales cycles," which basically means that many purchasers decided to postpone buying.



TOM LULEVITCH

A survey of management-information-systems (MIS) executives conducted by International Data Corp. in the waning days of 1987 found that computer managers expected their information-systems spending to grow by only about 1 percent in the next 12 months. Just six months earlier, MIS managers had anticipated a more robust 5 percent growth rate.

At first glance, the drop doesn't seem related to the crash. Almost four-fifths of the MIS executives polled said the event would have no impact on their 1988 spending plans. Only 7 percent said the crash would cut spending.

Ah, but which 7 percent? A closer look reveals that the pessimists included a disproportionate number of companies with big-buck budgets.

This could spell trouble, but barring more bad news, I predict buying will firm up through the second half of this year. International Data projects 5 percent growth in the value of multiuser-system shipments in 1988—7.5 percent internationally, but only about 3 percent in the United States.

That's relatively good news. The bad news is that even before the crash, there was an underlying softness in the U.S. computer market. Nothing indicates that the industry will return to the heady days of unrestrained growth that preceded the 1985 downturn.

Above the personal-computer level, last year's talk of an industry rebound sounds hollow. International Data estimates that the value of U.S. hardware shipments for multiuser systems (everything from tiny DEC MicroVAX 2000s to Cray-2 supercomputers) was $25.7 billion in 1987, up only 2 percent from 1986. Large mainframes showed no growth, and medium systems struggled to hit the 2 percent average. Even the smallest systems eked out only 4.5 percent domestic growth.

The Great Softness is the result of the convergence of market maturation and the move to smaller systems. Market maturation can be seen in the increasing percentage of computers bought to replace installed systems. Today, more than half of all mainframe shipments retire existing computers, and about 20 percent of midrange systems are replacements. As long as performance requirements keep rising, maturation is not necessarily a problem, but the downsizing of critical applications onto distributed systems and potent microprocessor-based machines removes much of the headroom from mainframe growth.

A lot of companies seemed to do much better last year than analysis of market forces might suggest, but much of that growth came in depreciated dollars from overseas sales. Take away the windfall gains from currency conversion, and real international growth would have been almost down to the U.S. level. Also, many companies managed to grow only by snatching market share away from IBM. If Big Blue had been stronger, competitors' results might have been weaker.

The convergence of market maturation and downsizing will constrain growth for the next couple of years. Companies will have to find new sales by raiding their competitors while fighting to hold on to their own installed bases. Secondary industries that depend on growth, such as packaged software and peripherals, may do well for a while. However, their growth could bump up against a ceiling in a few years.

A certain degree of consolidation is inevitable, but even buyouts won't help the neediest companies. The hardest hit operations will not make the most attractive acquisition targets.

Despite all the attention, postcrash flutters in the computer industry are only a small part of the problem. Even before the crash, the outlook was not that rosy in the first place. ■

Donald C. Bellomy is a senior consultant in processor research at International Data Corp. of Framingham, Mass.

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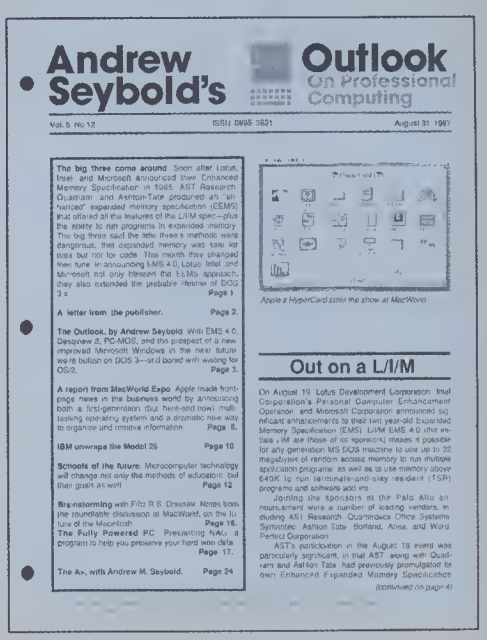

Andrew Seybold's Outlook On Professional Computing

Vol. 5 No. 12 ISSN: 0895-3821 August 31, 1987

The big three come around. Soon after Lotus, Intel and Microsoft announced their Enhanced Memory Specification in 1985, AST Research, Quadram and Ashton-Tate produced an "enhanced" expanded memory specification (EEMS) that offered all the features of the LIM spec—plus the ability to run programs in expanded memory. The big three said the new three's methods were dangerous, that expanded memory was safe for data but not for code. This month they changed their tune in announcing LIM 4.0. Lotus, Intel and Microsoft not only blessed the EEMS approach, they also extended the probable lifetime of DOS 3.x. Page 1

A letter from the publisher. Page 2.

The Outlook, by Andrew Seybold. With EMS 4.0, Desqview 2, PC-MOS, and the prospect of a new, improved Microsoft Windows in the near future, we're bullish on DOS 3—and bored with waiting for OS/2. Page 3.

A report from MacWorld Expo. Apple made front-page news in the business world by announcing both a first-generation (but here-and-now) multitasking operating system and a dramatic new way to organize and retrieve information. Page 5.

IBM unwraps the Model 25. Page 10

Schools of the future. Microcomputer technology will change not only the methods of education but then goals as well. Page 12

Brainstorming with Fritz R.S. Dressler. Notes from the roundtable discussion at MacWorld, on the future of the Macintosh. Page 16.

The Fully Powered PC. Presenting NAG, a program to help you preserve your hard-won data. Page 17.

The A>, with Andrew M. Seybold. Page 24

Apple's HyperCard joins the show at MacWorld

Out on a L/I/M

On August 19, Lotus Development Corporation, Intel Corporation's Personal Computer Enhancement Operation, and Microsoft Corporation announced significant enhancements to their two year-old Expanded Memory Specification (EMS). LIM EMS 4.0 (the initials LIM are those of its sponsors) makes it possible for any generation MS DOS machine to use up to 32 megabytes of random access memory to run multiple application programs as well as to use memory above 640K to run terminate-and-stay resident (TSR) programs and software add-ons.

Joining the sponsors at the Palo Alto announcement were a number of leading vendors, including ASI, Research, Quarterdeck Office Systems, Symantec, Ashton Tate, Borland, Ansa, and Word Perfect Corporation.

ASI's participation in the August 19 event was particularly significant, in that AST, along with Quadram and Ashton Tate, had previously promulgated its own Enhanced Expanded Memory Specification

(continued on page 4)

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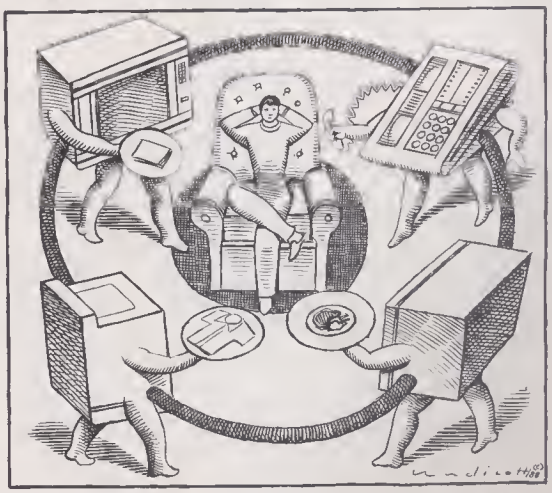
Smart-House Standards

TEAMWORK EMBODIES THE JAPANESE APPROACH

■ **By Robert Chapman Wood**

THE JAPANESE are good at teamwork, and the Japanese government and leading electronics companies are taking advantage of that skill in their approach to the "smart" house, in which consumer electronics products communicate with one another. The program's coherence could make Japan the world leader in home-automation technology.

While many U.S. companies and organizations are also working on smart-house products (see "Companies Struggle to Automate Homes," March 1988), the Japanese believe they are taking a more long-term approach to creating electronic networks in the home. The heart of the effort is a standard for wiring that would equip a house with "information outlets," devices similar to power outlets and telephone jacks. Each information outlet would connect to at least one coaxial cable—eventually fiber-optic cables—and at least two twisted pairs of copper wire. The standard includes guidelines for moderate-bandwidth channels to handle computer data and telephone calls, as well as high-bandwidth channels to carry video programming.



JAMES ENDICOTT

Unlike U.S. efforts to create home networks, which focus on introducing specific products over the next few years, Japan's information outlets and the communications systems that would link them are designed for technologies that may affect homes over the next several decades.

Today, Japanese home-automation products do not differ radically from U.S. products. The leader is the HALS system from Matsushita Electric, which can turn on coffee makers, control security systems, and monitor appliances such as air conditioners.

HALS and other home-automation products in Japan work through a house's existing electrical wires, as do current smart-house products in North America. In most cases, interference in these wires results in relatively slow data-transmission speeds of less than 1,000 bits per second. However, a Japanese government/industry group called the Electric Power Line Information Transmission Research Committee has proposed a new way to send data through existing electrical wiring at 9,600 bits per second—fast enough for computer networking and high-speed digital facsimile transmission.

This new technique uses "spread-spectrum" communications technology to control electrical noise on the wires by sending data on several frequencies at once. The committee established specifications for this effort, but Japanese electronics-industry executives say it could be years before products based on the proposed standards reach the market. NEC, however, is already working on a power-line home communications system called Spectrum AC (see "Look Ma, No Wires," p. 12).

In the meantime, Japan's semi-official standard-setting efforts have placed top priority on rules for hard-wired connections to allow information transfer in the home. Data flowing through a house's power lines might eventually act as a subsystem of the network. For example, a computer may be able to send audio or video signals to the information outlets in the house while simultaneously controlling appliances through the power lines.

Unlike the U.S. approach, the Japanese system, dubbed the "home bus," was not designed to support specific products. The Japanese attempted to create standards to accommodate any conceivable future technology. Twelve Japanese electronics companies developed prototype smart-house systems for consideration by the Home Informatization Research Council. The most complex approach was Matsushita's Savtec system, which accesses television and electric power lines while sending digital data over coaxial cable, as well as over electric and telephone wires. Other house-automation systems were presented by Toshiba, Sony, Sanyo, NEC, Sharp, Hitachi, Mitsubishi Electric, Nippon Telegraph and Telephone, NHK (Japan Broadcasting Corp.), and Oki Electric.

Japanese electronics-company officials say they intend to apply their standards only in Japan. Although some Japanese companies criticize Western standards-development groups for short-sightedness, the Japanese say they will also manufacture products to suit the standards adopted in other countries around the world. However, to the extent that Western smart-house developers still lack a clear vision of how homes of the future should be wired, the Japanese standards may well influence what standards get adopted in the rest of the world. ■

Robert Chapman Wood is an analyst and business consultant who specializes in technology and the Japanese economy.

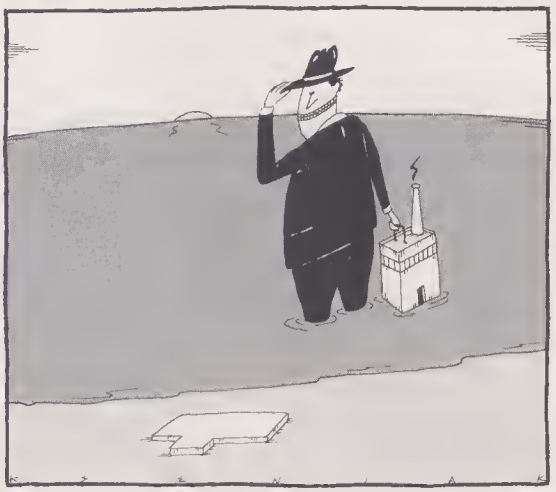
Making It Overseas

OFFSHORE MANUFACTURING CARRIES RISK, REWARD

■ **By Stephen M. Andress**

A GROWING NUMBER of high-technology businesses are looking to manufacturing in foreign countries as a way to gain competitive advantage. The chief incentive has usually been lower labor costs, and the rewards can be high. However, unforeseen problems can erode many of the immediate advantages.

Local laws restricting foreign investment, weak protection for technology, U.S. export controls, and currency-exchange rules can affect the structure, scope, and profitability of foreign operations. The interplay of U.S. and local laws requires careful analysis and coordination, and companies considering a move offshore—as well as their investors and creditors—must be aware of the potential for pitfalls as well as profits.



MARK KSENIAK

To help ease the situation for U.S. companies, many countries have lowered legal and trade barriers in an attempt to lure high-tech manufacturing operations. Ireland, for example, has implemented an incentive program to attract companies with ambitions in Europe. Average rates of return on U.S. investment in Ireland exceed 30 percent, and more than 350 U.S. companies, including Digital Equipment Corp., Wang Laboratories, Prime Computer, AT&T, and Amdahl, have operations in Ireland. These companies benefit from generous government startup and training grants, duty-free access to the European Economic Community, effective tax rates approaching zero, and an abundance of cheap and productive workers.

Mexico has also set its sights on foreign business. Its recently expanded "maquiladoras" program gives special regulatory consideration to production-for-export operations.

Some countries—including Ireland, Japan, and Mexico (in its maquiladoras program)—permit 100-percent foreign ownership, but many other nations do not. Investment laws can limit foreign ownership of businesses, mandating the creation of joint ventures with local interests. These requirements, often combined with local laws that invalidate protective clauses in licensing agreements, can loosen a foreign company's control of its overseas operations. Even worse, minority-interest protection provisions are often either ineffective or unenforceable under local corporate and contract laws.

Such laws effectively require U.S. companies to share their technology with foreign nationals, and can entangle manufacturers in U.S. export regulations (see "Exports: Handle With Care," May 1988). These rules place burdens on the flow of information to Eastern bloc countries, but even when dealing with non-Communist countries the regulations are complex and penalties for even unintentional violations can be severe.

Another crucial issue is the degree of protection afforded by a host country's patent and trade-secret laws. In Japan, where the government opens patent applications to the public long before it issues a patent, proprietary technology is often exploited with impunity. One small California semiconductor-design company sold a sample product to a large Japanese concern at a trade show, and later found that the buyer had filed 120 Japanese patents on what the U.S. company felt was its proprietary technology. The U.S. company did not have the resources to breach this wall.

To keep pace with the fast-moving Japanese market and that country's open season on technology, U.S. companies must make a substantial commitment to maintaining a presence in Japan. Many smaller companies cannot handle that expense.

Many countries also have exchange controls that limit access to foreign currency and restrict repatriation of capital and profits. Such regulations can turn otherwise successful enterprises into failures by trapping profits in the country where they were earned.

The joint-venture guidelines announced last year by the Soviet Union state that all foreign-currency requirements—including dollars to return profits and other payments to foreign interests—must be met from the export revenues of the Soviet joint venture. Coupled with an artificially controlled exchange rate that overvalues the ruble, the USSR's exchange controls make access to the vast Soviet market of questionable value.

Other legal issues, including antitrust, labor, and tax laws, also affect foreign operations. But a few countries are doing their best to ease the burden. With proper planning, coordination, and persistence, offshore manufacturing can provide enough of a competitive edge to make the lure irresistible. ■

Stephen M. Andress is a partner in the High Tech and International Groups of Nutter, McClennen & Fish of Boston.

The Constrained Curve

The Constrained Curve

The geometric path traced by a robot arm is independent of time. Now a mathematician at the General Motors Research Laboratories has devised a simple, innovative way to relate the path to time so that the machine can track the path and meet specific performance objectives without exceeding its physical operating limits.

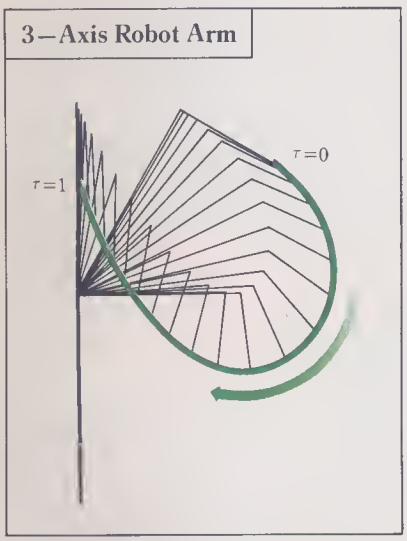


Figure 1: Schematic diagram of a 3-axis robot tracing a path in 3-space.

Industrial robot arms are very good at repeating a well defined motion with a high degree of accuracy. A robot with a welding tool, a paint sprayer, or a grasping device at its tip can weld in the right spot, spray a precise pattern, or locate a part in a given place time after time.

This untiring precision makes robots valuable in a quality-oriented manufacturing process such as the assembly of an automobile. That's why General Motors has installed so many robotic manipulators in its plants, and why GM is intent on developing technology and software to use these machines to their best advantage.

When a robot is to apply sealant to a windshield opening, or move a part from one point to another, its tip is positioned at points along a fixed geometric path, always maintaining the orientation needed to perform the task.

Mathematically, tip position along the path can be described as a function of a one-dimensional position parameter τ that ranges from 0 to 1 as the path evolves from beginning to end. Actually, for a robot having three joints, Figure 1 for example, tip position is determined by a set of three functions of τ, one for each joint of the arm. Each separate joint function relates a specific angle of rotation, θ, about that joint axis to a given value of τ.

To get the robot to perform a task, however, its computer controller must associate each point on the path with some value of time—in effect telling the robot to be in position A at a certain time, position B at another time, and so on, throughout the path.

Establishing an appropriate correspondence between time and the path position parameter is an important prerequisite to actually controlling the robot to follow the path.

Dr. Samuel Marin, a mathematician at General Motors Research Laboratories, has devised an effective and efficient means of computing the required correspondence. His work addresses productivity concerns. Dr. Marin's objective is to make cycle time (the time it takes the robot to trace the path from beginning to end) as small as possible, yet to respect at all times the physical operating limits of the robot.

Dr. Marin noted that by seeking a correspondence that gives time explicitly in terms of the path position parameter, t=h (τ), the problem's character changes. It appears not so closely associated with control theory, where the problem has also been studied, but more like a problem of nonlinear optimization.

Setting $g(\tau)=h'(\tau)$, the derivative of h with respect to τ, allowed Dr. Marin to pose the minimum time prob-

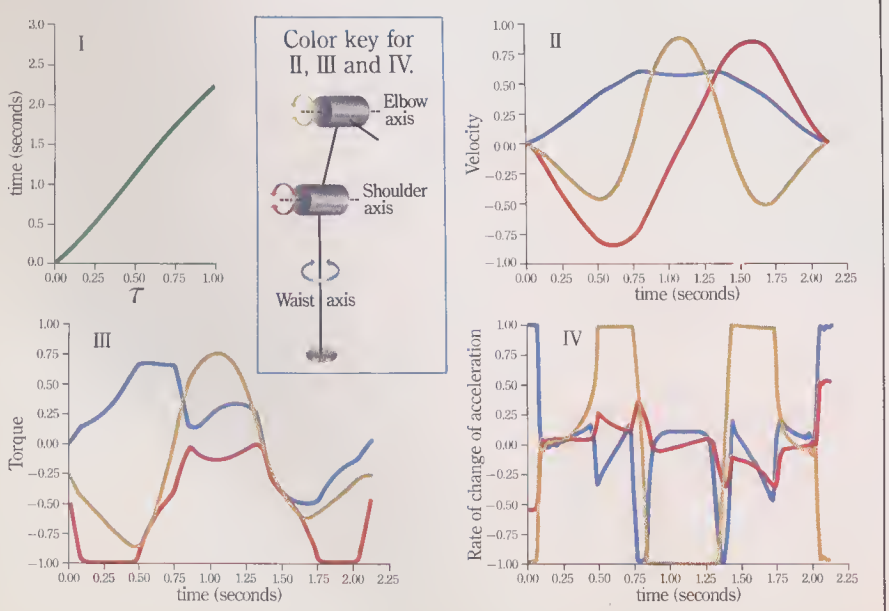


Figure 2: Results for Figure 1 path. I: Plot of the change of variables, t=h(τ). II, III, and IV: Normalized velocity, torque, and rate of change of acceleration for the waist, shoulder, and elbow (for any variable, a value of ±1 indicates operation at a limit).

lem in the following way: minimize $\int_0^1 g(\tau)\, d\tau$, subject to some constraints dictated by the physical operating limits of the robot mechanism. These limits on the robot—limits on velocity, acceleration or torque, and on rate of change of acceleration (Fig. 2)—can all be formulated as differential inequality constraints and are all expressible in terms of the unknown function $g(\tau)$, as: $g(\tau) \geq G(\tau, g, g', g'')\ \tau \in [0,1]$.

If the problem could be discretized, making it in some sense finite, it could be put on a computer and solved numerically. So Dr. Marin replaced the unknown function with a piecewise cubic approximation.

This allows the search for the unknown function to be confined to a class of functions that are completely characterized by a finite number of coefficients in a B-spline series.

He similarly discretized the constraints, replacing the infinite set of constraints with a finite dimensional subset that could be dealt with numerically.

He completed the formulation of the discrete problem by incorporating a grid-refinement strategy. Now the problem's dimension could be gradually increased to better approximate the continuous case.

What resulted was a classic nonlinear optimization problem, a finite dimensional problem in which it remained only to find the coefficients of the B-splines while satisfying the constraints.

A monotonicity property of this problem coupled with properties of the approximation method suggests that the simple technique of cyclic coordinate descent might best provide a solution.

"While not so effective in other applications, a cyclic coordinate descent-based algorithm appears to be exactly what is needed in this class of problems," notes Dr. Marin. "With modifications introduced to ensure that the iterates are strictly feasible, this method has consistently and rapidly solved the problem."

Working closely with mathematicians at Rensselaer Polytechnic Institute, Dr. Marin is confirming this method's utility. In comparisons so far with several widely used, general-purpose optimization codes, the special method consistently shows itself to be superior.

"My work in path parametrization is just part of the story here at GM," emphasizes Dr. Marin. "Many aspects of this problem's formulation are rooted in deeper concerns about how robots can be made to move faster and more accurately. These concerns originated in the work of Dr. Robert Goor, my colleague in the Mathematics Department, and have motivated several significant advances in robot control and trajectory planning.

"Until all the pieces are put together in a production system, it's difficult to gauge the full value of this work. However it will help reduce our manufacturing costs and will enhance our product quality."

THE MAN BEHIND THE WORK

Dr. Sam Marin is a Senior Staff Research Scientist in the Mathematics Department of the General Motors Research Laboratories. He is also the Manager of the Department's Mathematical Analysis and Computation Section.

Dr. Marin received his undergraduate degree in mathematics from St. Vincent College in Latrobe, Pennsylvania, and holds both an M.S. and a Ph. D. in that discipline from Carnegie-Mellon University. Between graduate degrees, Sam was an officer in the U.S. Navy, teaching mathematics at the Naval Nuclear Power School.

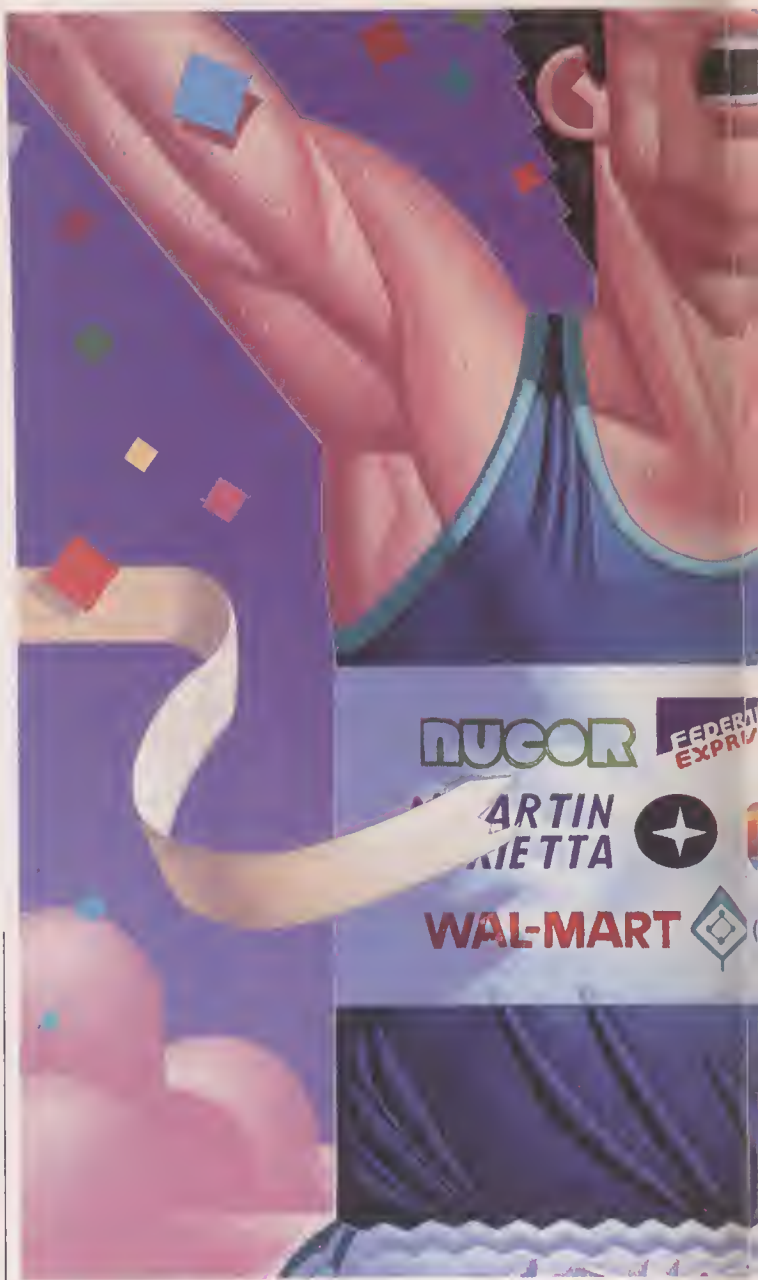
Since joining General Motors in 1978, Dr. Marin has pursued interests in numerical analysis and approximation. He has published research relating these areas to a variety of applications, including robotics, geometric curve design, and acoustics.

Sam is a member of the Society for Industrial and Applied Mathematics. He lives in Rochester Hills, Michigan, with his wife and two children.

America's Technology Champions

An exclusive survey tells which companies are putting high tech to work

BY HERB BRODY



American business suffers from no lack of technology. If anything, companies are overflowing with an astonishing—even bewildering—array of computers, telecommunications gear, and "factories of the future." The ability to use technology in daily operations is often considered more important than packing advanced technology into the company's products.

What makes a technology champion? HIGH TECHNOLOGY BUSINESS answers that question by examining 10 companies that are considered the technology leaders of their industries—their profiles begin on page 24. To find these superusers, we polled experts in each of 10 major industries (see "The Best at Putting Technology to Work," p. 34.). Analysts and company chiefs rated the 20 largest companies in these fields—ranking them not according to the technical merits of their products, but rather on how well the companies use technology *internally* to improve the bottom line. We chose the 10 winners based on the survey results and additional interviews with analysts.

Though the 10 stories are diverse, some common themes emerge. Generally, we found that the best use of technology results not from the unbridled acquisition of leading-edge hardware, but from innovative and disciplined management. Most of the winning companies boast reputations as well-run enterprises in all areas. The winners encourage risk-taking, foster communication, and look for the many less-tangible benefits of advanced technology.

We found that technology champs are usually not the largest companies. For example, Apple topped IBM in the computer/electronics category, Nucor swamped USX among steel companies, and Martin Marietta knocked off such defense-contracting goliaths as Boeing, McDonnell Douglas, and Rockwell International. The largest corporation of all, General Motors, was cited for its inability to effectively use the vast amount of technology it has purchased.

Indeed, many companies stumble by trying to "smear technology on top" of their existing business, says Michael S. Scott Morton, a management professor at the Massachusetts Institute of Technology. Morton, who is directing a five-year study on management in the 1990s, asserts that such a superficial approach improves performance by only about 10 percent—a small gain from the significant investments typically required to bring in advanced communications, data processing, and office- and factory-automation systems.

Replacing workers with robots, for example, won't fix productivity problems. For robots and computer-controlled machines to pay off, a company usually must reorganize its

whole production operation. That might mean laying out the plant so that an entire product is manufactured in one area. By contrast, many of today's factories group machines in ways that require products to make their way along paths resembling cooked spaghetti.

Successful users of technology tend to emphasize teamwork among departments that ordinarily operate separately, or even in conflict. This is especially true of a company's technical and business leaders. "They have to spend a lot of time together," says Michael Packer, director of information technology at the MAC Group, a management-consulting firm.

Another vital link involves the people who design products and those who figure out how to produce them. Traditionally, designers have stressed function and styling, giving little thought to how easy a product will be to build. As a result, many products cost crippling sums to produce. U.S. companies are finally starting to lock their designers and manufacturers in the same room. An example is the way Xerox responded to Japanese inroads in photocopiers, says MIT's Morton. Xerox restructured its operation, giving responsibility for each product to a team of designers, manufacturers, and marketers.

Getting design, manufacturing, and marketing to work together is crucial, agrees John Ettlie, a University of Michigan professor specializing in organizational issues of factory automation. Ettlie studied more than 50 U.S. organizations and found that the successful ones have made administrative changes to integrate technology more effectively. At several companies, for example, blue-collar workers participate in the design of automated factories; involving the front-line troops fosters a sense of commitment that is often missing when new technology gets handed down from top management. Moreover, the resulting system works better because shop-floor workers "know what's hard to implement and what's easy," says Ettlie.

The same idea pertains to white-collar environments. Harvard University professor Jim Cash, a specialist in management-information systems, says it's important to assess the "awareness of technology outside of a company's technology groups." The reason: Many innovative uses of technology "originated with people trying to get something done—not in the data-processing department," asserts Cash. Du Pont, for example, has become one of the world's leading users of artificial intelligence because of demands from its workers.

For all our technology winners, much of their success depends on that nebulous entity—corporate culture. For example, companies that use technology well tend to encourage risk-taking. "You need a culture that says it's okay to fail now and then," says Thomas Davenport, director of research at Index Group, a consulting company that focuses on management-information technology.

THE 10 WINNERS

Aerospace/defense	Martin Morietta
Computers/electronics	Apple
Finoncial services	Citicorp
Food processing	Archer Daniels Midland
General manufacturing	3M
Oil/chemicals	Du Pont
Pharmaceuticals	Merck
Retail	Wal-Mart
Steel/metals	Nucor
Transportation	Federol Express

Not that rampant adventurism is necessarily the ticket to better earnings. There's little benefit to being on the "bleeding edge," says Packer.

Companies hesitate to adopt unfamiliar technology in part because of difficulty quantifying its benefits. Technology advocates see their capital requests wither without the promise of payback expressable in hard numbers. "The most common problem businesses have with implementing technology is how to figure out the benefits," says Index Group's Davenport. It used to be easy, he says; machines justified their existence by cutting costs, often by directly replacing workers.

But that kind of direct substitution—which MIT's Morton says "even the accountants can understand"—is becoming rare. Instead, the benefits of advanced technology are more subtle, such as the ability to rush a product from design to market more quickly than the competition.

"It's critical to look beyond cost/benefit analysis," concludes Harvard's Cash. "Companies that let simple financial arguments dictate how they do things fail to ask the right questions" and wind up choking on the dust of more farsighted competitors.

HIRO KIMURA

Martin Marietta

To win government contracts in the aerospace and defense business, a company must develop and manufacture products less expensively but with higher quality than its competitors do. Over the last several years, Martin Marietta has won a spectacular 58 percent of the contracts on which it has bid, says Paul Nisbet, senior aerospace analyst at Prudential-Bache Securities.

This success rate is due at least partially to Martin Marietta's investments in technology, which keep it on the cutting edge of product development, design, and manufacturing, says Peter Aseritis, vice president of research at Smith Barney Harris Upham. The $5.2-billion company enjoys a record $10.8 billion in order backlogs, which Aseritis calls the best ratio in the entire industry.

	1987	CHANGE FROM 1986
■ SALES	$5.2 billion	+8.7%
■ PROFIT	$231 million	+14%

■ TECHNOLOGY-USE STRATEGY
Capitolizes on highly automoted computer-integrated manufocturing to reduce costs, thereby copturing government contracts.

■ Martin Marietto
6801 Rockledge Dr.
Bethesda, MD
20817
(301) 897-6000

Three projects showcase Martin Marietta's commitment to making technology work: the LANTIRN targeting system for jet fighters, the Strategic Defense Initiative National Test Bed, and the upgrade program for Titan rocket boosters.

The $608-million LANTIRN program (the name stands for "low-altitude navigation targeting infrared night") makes laser systems that help computerized weapons locate targets day and night in all kinds of weather. The program relies on a new, paperless factory in Orlando, Fla.

This automated plant fosters the efficiency needed to turn a profit on the fixed-price LANTIRN contract, says Robert Morra, Martin Marietta's vice president for technology operations. The company has invested more than $20 million to make the plant a prototype for future operations. It has such advanced features as a computerized information system that gives workers explicit electronic instructions for each job—tailored to an individual's experience level.

Such systems elevate the factory's efficiency to a point where less equipment is needed, says Morra. Productivity is up 200 to 300 percent, space savings average 40 percent, labor costs are down 45 percent, and both cycle time and inventory have been cut 75 percent. At the same time, yields have gone from 50 percent to 90 percent.

"The savings are real," Morra says, "and they will make us much more competitive on future bids" as Martin Marietta brings the technology to other factories. "Once we learn how to do it," he says, "we'll apply it everywhere."

At the National Test Bed of the Strategic Defense Initiative (SDI) in Colorado Springs, Colo., Martin Marietta has set up a facility that simulates all aspects of Star Wars command and control. The facility provides valuable test data before components are completed. The fact that the simulation was up and running during the bidding process "so impressed the SDI people that Martin won the [$508-million] deal over Rockwell," says Aseritis.

Martin Marietta's Titan rocket boosters are one of the longest running U.S. space programs, partly because the company keeps improving manufacturing. "They've had an incredible string of product improvements, with vastly increased reliability," says Prudential-Bache's Nisbet; the Titan program could become the U.S. space program's first 50-year-old production line.


Norman R. Augustine
Vice Chairman and CEO

HERMAN FARRER

Morra says the Titan rocket plant in Denver has doubled throughput compared to the 20-year-old technology previously used, and the goal is to trim 30 percent off manufacturing and test costs.

Even though Martin Marietta is involved in many sophisticated projects, Nisbet says, "the company has had very few technology hiccups and no devastating problems. They're doing something awfully right."

—*Fredric Paul*

THE RUNNER-UP: TRW

Picking the technology chomp in the aerospace ond defense industry is no easy motter. In the survey results, only o slim margin seporoted TRW, Northrop, ond Lockheed from the leader, with Roytheon running close behind.

Several onolysts, however, note TRW's innovative odoptotion of specialized datobase-management systems developed for military applications. TRW has turned these systems into products for internol use and commerciol soles. Robert Kugel, aerospace onalyst at Morgon Stanley, says the company's stote-of-the-art development and production programs couldn't be done without superior technology-management copobilities. Rather than any one particular program, he says, TRW's overall use of technology contributes to its success.

Apple

Apple Computer began life as the classic high-tech startup, with founders Steve Jobs and Steven Wozniak tinkering their way to a revolution. Today these garage-shop roots are part of a dim past, as Apple makes zealous use of technology.

"The first Apple computers were made by midnight oil," says analyst Gordon Casey of Fahnestock, a brokerage house. But the debut of the Macintosh in 1984 forced Apple into the high-tech manufacturing age. The product's success hinged on high-volume production and very high quality, and the company hit its first time at bat. The Macintosh manufacturing plant in Fremont, Calif., "is easily one of the best computer factories I've seen—at least as good as IBM's," says William Easterbrook, senior vice president of Dean Witter Reynolds.

	1987	CHANGE FROM 1986
■ SALES	$2.66 billion	+40%
■ PROFITS	$217 million	+41%

■ **TECHNOLOGY-USE STRATEGY**
Promotes an exceptionolly efficient manufocturing operation; Macintosh-bosed communicatians netwarks reach every desktop.

■ Apple Computer
20525 Mariani Ave.
Cupertino, CA
95014
(408) 996-1010

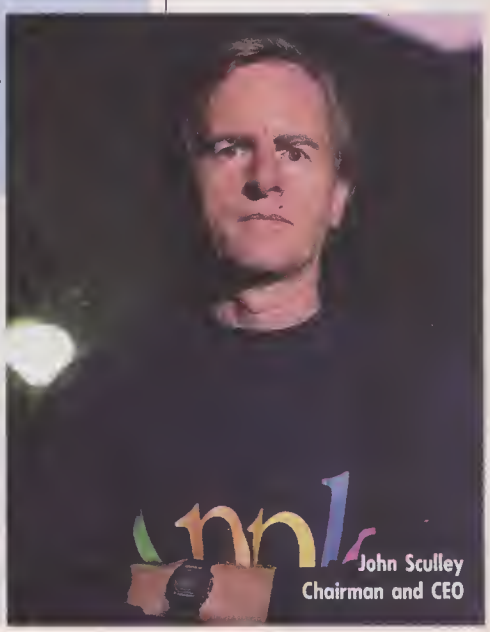
Not only do Macintoshes roll off the assembly line, they're used by Apple supervisors to monitor and control manufacturing equipment. The computer's easy-to-use set of graphic commands makes it accessible to shop-floor workers who would be intimidated by traditional computers, says William Stoddard, director of the manufacturing practice at management consultant Arthur Anderson.

Intelligent manufacturing is paying handsome financial dividends. Analysts hail Apple's gross profit margins of more than 50 percent; other computer makers muddle along at about 40 percent. Manufacturing efficiency contributes heavily to Apple's impressive performance, says Merrill Lynch analyst Melinda Reach.

As computers get more complex, and as the lifespan of a particular model flashes by in about 18 months, the design process assumes greater importance. "Automated design and testing is now the deciding factor regarding profitability," says Reach. That's why Apple purchased a $15-million Cray supercomputer to help simulate and test the next generation of Macintoshes. The Cray offers computational speed and power never before applied to personal-computer design; Apple engineers use it to optimize the complex interplay of often competing design factors such as cost, ergonomics, and manufacturability. (Meanwhile, at Cray Research in Minneapolis, engineers are using Macintoshes to design their next generation of supercomputer.)

The Cray purchase raised some eyebrows, because companies of Apple's size usually share time on someone else's supercomputer. "I was astounded," says Easterbrook. Even when products designed on the Cray hit the market in several years, it may be hard to assess the contribution made by the advanced technology. The best measure of the supercomputer's worth is the amount of time it is used, claims Easterbrook. "If they can keep that beast occupied even half the time, then it will have been worthwhile," he says. Allan Loren, Apple's vice president for information systems and technology, will only say that the Cray stays "very busy."

A Macintosh computer sits atop virtually every desktop at Apple. These machines are woven into a communications network called AppleLink, which provides electronic mail, company bulletin boards, and various databases, including proprietary information on product development as well as monthly sales figures. The network serves about 8,000 Apple employees and about as many affiliates, including dealers and third-party product developers.



MARK HANAUER/ONYX

Figuring the hard-dollar payback for such a network has proven difficult. Says Loren, "We know in our gut that if we got rid of what's on the desktop we'd need a lot more people around here."

Indications are that Apple's ferocious use of technology will continue. Deborah Coleman, a key force behind the ultramodern Macintosh factory, has risen to chief financial officer—a position occupied at many companies by a technology-squelching accountant.

—Herb Brody

THE RUNNER-UP: HEWLETT-PACKARD

Hewlett-Packard recently opened a highly outomated facility that assembles computer terminals more cheaply than do most competitors. When designing the terminal, engineers were required to create a unit thot could be easily assembled from readily available parts. The low manufacturing cost stems largely from this forsighted opprooch.

The company's use of technology daesn't stap at the factary gate. Five years ago, Hewlett-Packard was the first company to set up a corporate television network. An electronic-mail system that reoches 70,000 of its 82,000 employees is being upgraded with voice mail.

Hewlett-Packard runs its 60 semi-outonomous divisions with entrepreneuriol gusto. "We let people know that it's OK to fail sometimes," soys vice president Harold Edmondson.

Citicorp

Providing financial services is an exercise in collecting, processing, and disseminating information. Recognizing this, Citicorp makes widespread use of advanced computer technology, says Paul Glaser, chairman of the company's technology committee. The New York bank spends an estimated $900 million annually on computer hardware, software, and research and development—about twice as much as its nearest rival, BankAmerica, and more than 11 percent of the combined annual technology outlays of all U.S. banks.

The payoff can be considerable. Take Citicorp's data-processing system for managing credit-card accounts, one of the most efficient in the industry, according to Brent Erensel, financial-services analyst for Donaldson, Lufkin Jenrette Securities. As a result of this efficiency, Citicorp's credit-card management costs are half the industry average, saving about $300 million per year. However, even the best technology couldn't prevent a loss in 1987, as Citicorp incurred a $4.4-billion expense to cover potential loan losses associated mainly with Brazil, Mexico, and Argentina. This was the company's first loss in more than 50 years.

	1987	CHANGE FROM 1986
■ ASSETS	$203.6 billion	+4%
■ PROFIT	–$1.1 billion	–208%

■ **TECHNOLOGY-USE STRATEGY**
Improves banking and other financial services to attract more customers; reduces costs through more efficient data processing.

■ Citicorp
399 Park Ave.
New York, NY
10048
(212) 559-1000

Many of Citicorp's technology dollars go to develop new and better services (which attract more customers) and to reduce the cost of existing services. For example, to boost consumer banking, which brings in more than half the corporation's revenues, Citicorp established Transaction Technology Inc. in the early 1970s to develop electronic components for automatic teller machines (ATMs). A few years later, Citicorp became the first to use ATMs on a large scale, committing $100 million to install them in 203 branches within a matter of months. The impact on the New York City consumer-banking market was dramatic. "We tripled our market share," Glaser says.

Today, about 60 percent of all the bank's consumer transactions are handled by ATMs, says Mark Gibson of Retail Planning Associates, a consulting company employed by Citicorp. Without these machines, "the bank would need twice as many tellers," he says.

Citicorp is one of the few banks using touchscreen ATMs on a large scale. These machines have pull-down menus, available at the touch of a finger, to handle more functions than conventional pushbutton systems.

Such features are expected to pay off in the future, when banks plan to offer an array of services through ATMs, including money-market funds, discount brokering, mortgages, and sales of travel and entertainment tickets, says consultant Stuart Crane of technology think-tank Battelle Memorial Institute. Citicorp has a jump on the competition in expanding ATM services, says Crane, because its automatic teller software is flexible enough to accommodate additional services. Citicorp develops many of its ATM technologies in one of the most extensive research-and-development testing facilities in the industry, says Jeffrey Kutler, technology editor at *American Banker*. In this lab, paid subjects test new banking systems in a simulated environment while hidden cameras record results for later analysis.

Analysts say some of the bank's aggressive attitude toward technology filters down from Citicorp chairman John Reed, who has an engineering degree from the Massachusetts Institute of Technology—quite an anomoly in the financial-services business.

John S. Reed
Chairman, Citicorp and Citibank NA

DEBORAH FEINGOLD/OUTLINE

In June 1986, Citicorp bought Quotron Systems Inc., a company that provides computerized financial information used by brokers and analysts. "The bank will add some bells and whistles to enhance the product, then use it internally and also continue to sell it," says Fred DeBussey, financial-institutions analyst at Fitch Investors, a bond-rating service. DeBussey says the purchase demonstrates Citicorp's commitment to advanced information processing for financial services.

—Randy Ross

THE RUNNER-UP: AMERICAN EXPRESS

American Express turns computing power into dollars. Its much-touted credit-card authorizing assistant—an artificial-intelligence program that approves credit purchases—just completed its test period and will be rolled out in July, says Robert Flast, vice president of technology. He predicts the system will boost productivity by about 30 percent.

To uncover patential new markets, American Express uses unique database-manogement software to search through its stores of customer infarmation. "The company is odept at identifying chorge-card volume ond those who might be interested in certain products," says Stephen Kindel, seniar editor at *Financial World* mogazine. As an example, he cites American Express' successful introduction of its platinum cord, aimed at young professionals.

Archer Daniels Midland

Archer Daniels Midland is not a name people see on their grocers' shelves, but consumers guzzle the company's products in huge quantities. The $6-billion grain-processing company pioneered the method for making high-fructose corn syrup, the main sweetener in Coke, Pepsi, and myriad other soft drinks. An innovative processing technique developed by Archer Daniels Midland (ADM) has contributed to its dominance as a soft-drink supplier—the company sells about 30 percent of the 70 billion pounds of corn syrup purchased annually by beverage makers. Now ADM is applying its successful formula to increase its competitiveness elsewhere: Other processing advances are giving the company an edge in high-volume production of ethanol, which is becoming increasingly popular as a pollution-fighting, performance-boosting gasoline additive.

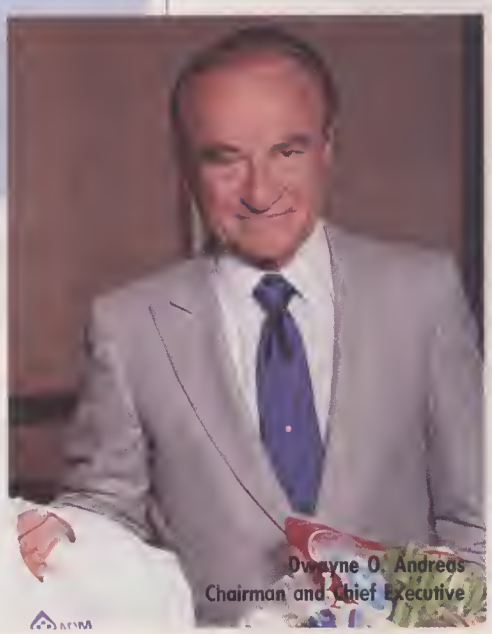
	1987	CHANGE FROM 1986
SALES	$5.8 billion	+8.2%
PROFIT	$265 million	+15.2%

TECHNOLOGY-USE STRATEGY
Develops continuous processes for producing large amounts of ethanol and high-fructose corn syrup.

Archer Daniels Midland
Box 1470
Decatur, IL 62525
(217) 424-5200

The company's corn-syrup business illustrates how sound technology management turns into dollars in the food business. Unprocessed corn syrup consists mainly of dextrose. But what soft-drink and food makers want is the sweeter fructose, which costs less and is much easier to handle than cane sugar, and therefore holds down bottling costs.

To make fructose, corn syrup undergoes a chemical process called isomerization, in which an enzyme rearranges dextrose atoms into fructose. Early batch processes were slow and inefficient, taking three days to yield a syrup containing only 42 percent fructose.


Dwayne O. Andreas
Chairman and Chief Executive

In the late 1970s, ADM thought up a new way to turn more of the dextrose into fructose. The idea was to abandon the batch approach and instead suspend enzyme particles in a long tube; dextrose would flow continuously through this enzyme-activated tube and emerge as high-fructose corn syrup. The problem was that fructose-making enzymes wouldn't work that way. "Our innovation," says research director John Long, "was telling our suppliers that we wanted that enzyme particle." This call for participation shows the company's willingness to tap innovations from elsewhere, a key to its success, says Long. "We don't have a 'not invented here' syndrome. We look at the world as our research lab."

ADM's continuous process converts as much as 95 percent of the dextrose to fructose. Since 1984, the soft-drink industry has used nothing but high-fructose corn syrup (in concentrations of 55 percent) to sweeten its products, consuming about 70 percent of the more than 11 billion pounds of high-fructose corn syrup produced each year industry-wide. ADM's technological acumen has more than paid off through its substantial market share.

Another ADM first—continuous fermentation of corn into alcohol—may have similar business ramifications. The company produces 500 million to 600 million gallons of ethanol a year, says Long, making it the largest U.S. supplier.

ADM developed this process to serve the growing fuel-additive market. As lead is legislated out of the gas pumps, other ingredients must be used to boost octane (the measure of gasoline's combustion quality). Alcohol produced by traditional batch fermentation costs almost $30 a gallon—"fine for vodka, but way too expensive for fuel," says Richard Burket, ADM vice president and assistant to the chairman. ADM prices its fuel-grade ethanol at less than $1 a gallon.

In addition to raising octane, ethanol lowers carbon-monoxide emissions, an advantage that is starting to expand its market. Last winter, the city of Denver decreed that only gasoline that contains ethanol could be sold; other smog-ridden cities, such as Los Angeles, are considering implementing similar restrictions.

—Herb Brody

THE RUNNER-UP: KELLOGG

In 1986, after 82 yeors, Kellogg stopped giving tours of its plont in Battle Creek, Mich. The company feared that spies might figure out some of its production secrets, such as haw it manoges NutriGrain, which incorporotes whole grain into a flake without sacrificing shelf life. "We don't discuss how we make cereol," says spokesmon Richard Lovell.

Beneath that veil of secrecy, Kellogg is doing something right. The company enjoys annuol earnings growth of 15 percent, accarding to Prudential-Bache onalyst John McMillin. He ottributes the company's 19 percent operating margin to efficient production.

Kellagg pays handsomely to put the crunch in its cereals. Last year it allacated $400 million in capital expenditures, including more than $200 million to modernize its flagship plant in Bottle Creek.

3M

The 3M 1988 Product Directory is 275 pages long, with about a dozen product descriptions on an average page—and those are just the *major* goods. In all, the 86-year-old company makes about 50,000 different products, from floppy disks to flea spray, from surgical staples to silicone sealer. 3M is a manufacturing machine, built on innovative research and development coupled with factory know-how that would make any Japanese company the envy of its island.

"A key strength of 3M is our ability to develop a broad range of new products and the associated processes to make them, using a wide range of technologies," says William F. Mackenzie, executive director of corporate quality and manufacturing services. Minnesota Mining and Manufacturing uses approximately 100 processes in its plants, says Mackenzie, who must mix and match these diverse technologies to achieve the highest quality at the lowest cost.

	1987	CHANGE FROM 1986
■ SALES	$9.4 billion	+9.6%
■ PROFIT	$918 million	+17.8%

■ **TECHNOLOGY-USE STRATEGY**
Emphasizes process control and manufacturing as integral elements of new-product development.

■ Minnesota Mining and Manufacturing (3M)
3M Center
St. Paul, MN
55144
(612) 733-1110

3M is a sales leader in many wildly dissimilar markets—it supplies industrial and electronic goods, commercial and consumer merchandise, health and safety items, and products for computer and imaging technologies. "3M's unit-volume growth universally exceeds growth in the market segments it serves," says Theresa Gusman, a Salomon Brothers vice president.

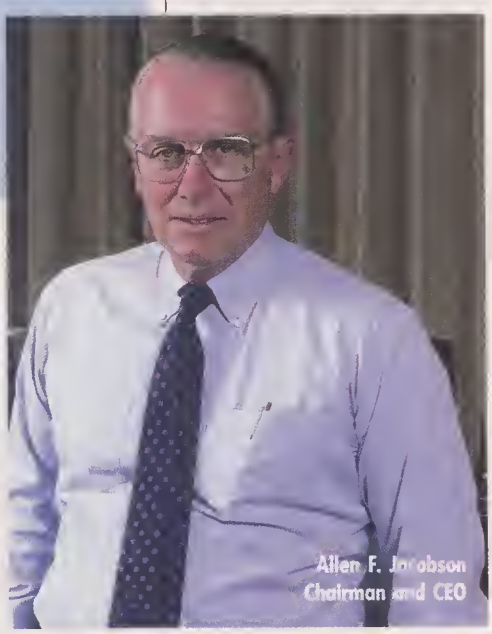
This success hinges on the company's close coupling of product development with manufacturing. 3M receives consistent praise for its innovative research and development—Gusman says a quarter of its sales come from products introduced in the last five years. But 3M recognizes that it's not enough to simply roll out well-timed new products from its research labs; at the same time, it pushes to develop manufacturing techniques to make products that will cost less, yet still outperform rival goods.

Take Post-it Notes, those removeable slips of sticky paper that have become as indispensible as the office coffee machine. Just as important as the discovery of the not-too-sticky adhesive that makes the product work was the development of the all-new process needed to apply a strip of the adhesive to paper and bundle the notes into pads.

This emphasis on process technology in manufacturing can lead to successful new products. For instance, says Mackenzie, 3M's line of protective facemasks for workmen followed from its expertise in making non-woven webs—mats of unmeshed fibers.

Assembly-line measurement and automatic inspection are priorities at 3M plants. The company is scouting new measurement systems that can provide immediate feedback to control computers, allowing the controllers to make automatic adjustments before a problem gets out of hand. The systems also feed measurements into factory databases for later analysis. "They will tell us more about what's going on in a process, and how it may affect the product for better customer satisfaction," says Mackenzie.

This emphasis on quality is part of 3M's five-year Optimized Operations program, designed to hone its manufacturing abilities. The program aims to reduce labor expenses, cut the cost of quality control, and shorten the time needed to make a product, each by 35 percent. Already the company has seen some impressive gains—for example, a tape-making plant that once took 30 days to spit out a finished roll now does it in about 20 minutes, says Mackenzie.


Allen F. Jacobson
Chairman and CEO
STEVE WOIT/PICTURE GROUP

The Optimized Operations project plays into 3M's corporate goal to increase its return on capital employed—the ratio of pre-tax profit to the value of plants and equipment, inventory, and accounts receivable. By 1990, the company plans to get a 27.5 percent return on its capital, and so far it's on target. When 3M began the program in 1985, return on capital employed was 20.3 percent. That figure rose to 23.5 percent in 1986 and reached 24.5 percent last year.

—Jeffrey Zygmont

THE RUNNER-UP: GENERAL ELECTRIC

Like other manufacturers, the most critical technology challenge for General Electric is control and coordination of equipment on the factory floor. "GE has always been ahead of the pack in manufacturing technology," says William Stoddard, a consultant at Arthur Andersen. Like 3M, GE recognizes that planning for factory efficiency has to start in the earliest stages of product design—goods must be designed so they are easy to make.

GE's dishwasher plant in Louisville, Ky., stands out for its elegant simplicity. A simple manufacturing operation gives workers fewer opportunities to make mistakes, says Stoddard, and results in higher overall product quality. Quality is important to GE; the company "sees the need to keep the Japanese out of its key markets," he says.

Du Pont

Compared to industries such as aerospace and electronics, the chemical business seems to offer little high-tech glamor. Du Pont has had its share of dramatic innovations—the development of nylon, for example, and Kevlar, the super-strong fiber used in bulletproof vests. But the technology that nourishes the company rarely makes headlines.

"Our biggest technical strength is not in the 'Eureka' invention, but rather in day-to-day applications," says Harvey McCumber, director of the engineering-services division. In the commodity chemical business, he explains, "reducing cost by even a tenth of a percent gives you an enormous competitive advantage." Du Pont draws heavily on advanced computer systems to wring greater savings from its daily operations.

	1987	CHANGE FROM 1986
■ SALES	$3.05 billion	+12.5%
■ PROFIT	$1.79 billion	+16.2%

■ TECHNOLOGY-USE STRATEGY
Uses artificial intelligence to optimize production of commodity chemicals; sells internal software-development systems to other companies.

■ E.I. Du Pont de Nemours & Company
Wilmington, DE 19898
(302) 774-1000

Du Pont is pouring millions of dollars into expert systems—artificial-intelligence software that mimics the problem-solving abilities of sages who have devoted their careers to learning the intricacies of industrial chemical processing. "We're cloning our experts," says Ed Mahler, Du Pont's program manager for artificial intelligence. Guided by an expert system, greener workers can handle such tasks as repairing complex equipment. "For every dollar we spend on expert systems, we get back 15 times that" in reduced maintenance and greater process efficiency, says Mahler.

Mahler started the expert-system program only two years ago, and already more than half of Du Pont's plants routinely use or are field-testing such systems, he says. In one typical setup, the software diagnoses problems with the control system at a distillation plant. When the system went awry in the past, workers often couldn't figure out which of its dozen circuit boards caused the problem—so they replaced them all, an expensive and time-consuming proposition. Du Pont's solution: Find a repair technician with an intuitive feel for the process and program his troubleshooting knowledge into the computer. Now every technician can fix the system at minimal cost.

The same result could be achieved in a low-tech fashion by having the repair guru train some disciples. But Mahler points out that "training is evaporative; people leave." An expert system is a permanent company asset.

Another example of Du Pont's commitment to using technology well is its investment in advanced computing. "They were the first in the chemical industry to get a Cray supercomputer," says Robert Warren, editor of *Chemical Business*. The Cray helps Du Pont researchers develop new classes of products—particularly pharmaceuticals, a business the company considers strategic to its future. For example, the Cray recently crunched numbers for 40 hours to generate a several-minute-long film showing the dynamic behavior of an especially complex molecule. A personal computer would have needed 18 months to make the same film.

Indeed, Du Pont is becoming a conduit leading other companies toward more economical data processing. Its automated software-development system, which uses computers to write other computer programs, is working so well that Du Pont has formed a separate organization to sell it to the outside world. Du Pont Information Engineering Associates (IEA) has grown from a staff of 17 last July to about 100 people to compete in the hotly contested market for computer-aided software engineering (CASE), according to general manager Scott Shultz. Its diverse clientele includes the FBI, General Foods, and the Christian Science church.


Richard E. Heckert
Chairman and CEO
DENNIS BRACK/BLACK STAR

Even before IEA began selling its services, the group had proved itself to Du Pont. In about 15 months, IEA produced 25 pieces of software for $2.3 million less than traditional programming methods would have consumed. On average, Shultz claims, IEA's methods increase the productivity of software development by 600 percent.

—Herb Brody

THE RUNNER-UP: AMOCO

Amoco, the country's sixth-largest oil company, has seized the technological high ground from its larger competitors. For example, Amoco is the leading user of tertiary oil-recovery techniques—pumping carbon-dioxide into wells to push up oil that has stubbornly refused to surface. By the end of 1987, tertiary recovery was producing an average of 12,200 barrels of crude per day for the company. Amoco's total oil production last year was about 1 million barrels a day.

Amoco draws heavily on computers to gain better control of the complex oil-refining process. By using such advanced technology, the company can get 86 percent more gasoline from a barrel of crude. To further develop its use of computers, Amoco is working with the National Center for Supercomputer Applications at the University of Illinois.

Merck

As a company that makes its living in pharmaceuticals, Merck and Company figures the best place to employ advanced technology is in its research labs. There, Merck is harnessing biotechnology and other techniques to add to its already impressive product line and find new ways to develop drugs.

The pharmaceutical giant makes more than 100 drugs, 13 of which generated sales of more than $100 million apiece last year. Even so, in 1987 Merck spent $650 million on drug research, a 15 percent increase over its 1986 allocation. That figure represents 15 percent of all the research money spent by major U.S. pharmaceutical companies last year.

	1987	CHANGE FROM 1986
■ SALES	$5 billion	+23%
■ PROFIT	$906 million	+34%

■ TECHNOLOGY-USE STRATEGY
Stays on the leading edge of laboratory development, creating new drugs with high earnings potential.

■ Merck and Company
8ox 2000
Rahway, NJ
07065
(201) 574-4000

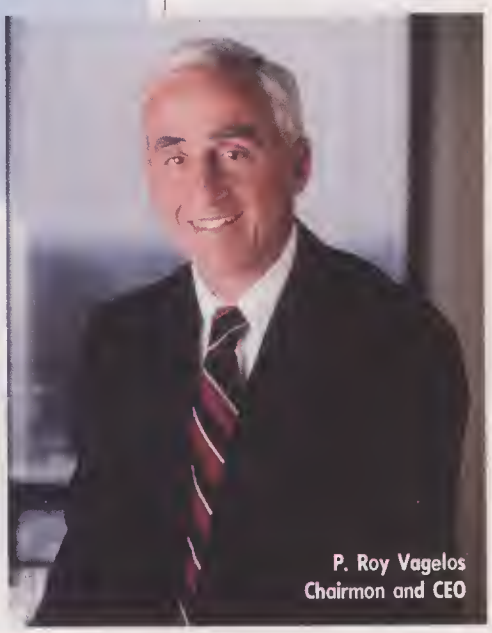
"The money Merck has spent has given it good results," says Ken Nover, a drug analyst with Daiwa Securities. Take the hepatitis-B vaccine, called Recombivax HB, the first genetically engineered vaccine approved for marketing in the United States. Even though Merck already offered its own conventionally engineered vaccine, it simultaneously funded research for the new vaccine at its own laboratories, as well as at Chiron Corp. of Emeryville, Calif., and two university medical centers. Today Merck markets both versions of the vaccine.

"Research is where they seem to use technology well," says Rita Freedman, a drug analyst with Provident National Bank. "New, innovative products like Mevacor [for lowering cholesterol levels] and Vasotech [for reducing blood pressure] came from their own labs." Analysts predict that within a few years Mevacor will have annual sales of more than $1 billion. One promising area of current research involves fibroblast growth factors, which are expected to be important drugs for wound healing. Merck has discovered one growth factor that has the potential to be used in a variety of ways, says Dr. Ronald Ellis, director of cellular and molecular biology for Merck Sharp & Dohme research laboratories.

Beyond developing new products, Merck is using biotechnology to study disease itself. "By studying receptors," says Ellis, "you can change the amino acids through genetic-engineering experiments to find out how the structure of an enzyme relates to its function." In layman's terms, this means Merck is looking for the minute, precise biological activity a drug should attack in order to stem the spread of disease or infection. "This research has only evolved over the last three or four years," says Ellis, "but it will be crucial to the next set of breakthroughs. These drugs will be more specific and cause fewer side effects."

Merck's activities include running a research center in England to study mental illness and brain disorders; a new facility in Rahway, N.J., for researching microbiology, genetics, recombinant DNA, and synthetic and process chemistry; a joint-venture lab in Rome for work on viral diseases; and a joint venture in Japan to develop drugs against cancer and infectious diseases. The company plans to expand its Canadian labs to study respiratory diseases and allergies.

"What sets us apart," says Ellis, "is that we have resources to put behind the development of biotech products. Other companies may only be able to start the process, but we have the resources to take it all the way through." That goes beyond developments in Merck's own labs. Last year the company signed on to fund research in AIDS vaccines by Repligen Corp. of Cambridge, Mass. In exchange, Merck gets the rights to sell future products based on its partner's research.


P. Roy Vagelos
Chairmon and CEO

Merck has also agreed to fund cancer-drug research at Biogen N.V., another Cambridge biotechnology company. Biogen is developing recombinant proteins to treat cancer of the female reproductive tract. If the research proves successful, the products will be tested and marked by Merck—possibly adding another important drug to its line of products.

—Francesca Lunzer

THE RUNNER-UP: ABBOTT

Abbott Laborotories of North Chicago, Ill., has computer technology to thank for some of its emerging products, including several new ontibiotics. "We were omong the first in the industry to pursue the orea of computer-assisted molecular design," says Robert Jonicki, vice president for pharmaceuticol reseorch ond development. "This hos ollowed us to move owoy from just screening compounds to see how well they work." Insteod, the company simulates how compounds work "to creote much more specific molecules with fewer side effects."

Abbott has olso used sophisticated loboratory techniques to create its highly successful diognostic products. By coupling chemicals and computerized instruments, Abbott's test to detect ontibodies to the AIDS virus hos become the best-selling AIDS test in the United States.

Wal-Mart

At Wal-Mart Stores, advanced technology sustains a breakneck growth rate that makes the company the premier empire-builder of the retail industry. Computerized inventory-control systems electronically order merchandise from suppliers and maintain order in warehouse and distribution centers. Computers direct the rapid flow of merchandise from a store's receiving dock to its shelves. Wal-Mart's electronic systems also log each item sold, helping store managers reorder hot sellers and shun slow-moving merchandise.

The precision of Wal-Mart's inventory-tracking computer systems permits it to conquer new territories the way Caesar's legions marched through Gaul. "The only way a company like Wal-Mart can be so successful is to have an outstanding information system," says Sally Schaadt, a securities analyst at Fourteen Research. "Otherwise, it would be completely bogged down in merchandise."

	1987	CHANGE FROM 1986
■ SALES	$11.9 billion	+41%
■ PROFIT	$450 million	+37.4%

■ TECHNOLOGY-USE STRATEGY
Leaps aggressively on new inventory-management systems that help it reduce operating costs or improve customer service.

■ Wal-Mart Stores
702 S.W. 8th St.
Bentonville, AR
72716
(501) 273-4000

In 1988, Wal-Mart plans to open about 150 new stores, bringing its total to about 1,200 outlets—mostly discount department stores—in 24 central and southeastern states. In fiscal 1987, the company's earnings jumped more than 40 percent; revenue growth has exceeded 30 percent for more than 10 years. This has placed Wal-Mart among the top five U.S. retailers, in the company of Sears and J.C. Penney.

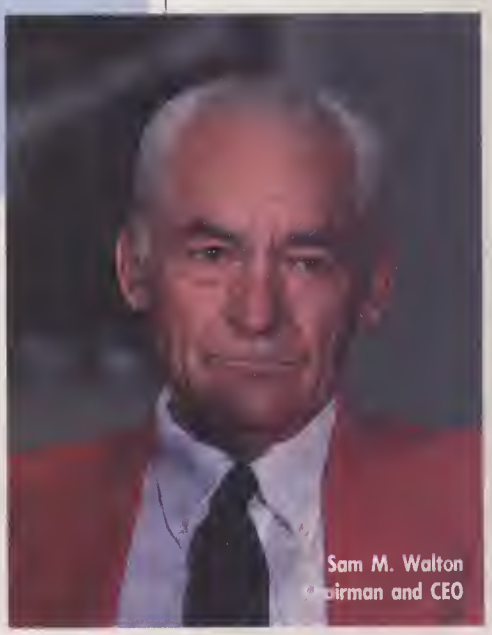
Wal-Mart's earnings keep pace with its rapid growth in revenue, because the company's aggressive technology programs aim at cost reduction. "They are always trying something new if it will save them labor costs, if it will save them time, or if it will lower costs for their customers," says retail analyst Linda Morris of Provident National Bank.

The retailer's latest technology feat is the Wal-Mart Satellite Network—WSN—a multimillion-dollar, 2½-year project to join more than 1,200 Wal-Mart facilities in a private, two-way satellite communications network—the world's largest, claims the company. In WSN's inaugural broadcast on January 11, chairman and founder Sam Walton appeared on television at Wal-Mart stores, leading the company's more than 185,000 employees in a simultaneous Wal-Mart cheer.

Many other companies have set up private television networks to train and communicate with employees. But Wal-Mart adds electronic data communications to the usual audio and video transmission. That means store managers can send electronic messages instead of paper mail. Within seconds, a store can tell its distribution center that it needs more of a fast-selling item, keeping shopping carts brimming and cash registers ringing.

Rapid and reliable communication, along with accurate information collection, are key to Wal-Mart's success. To collect and transmit data better, last year the company refitted its 12 distribution centers with new laser-scanning systems that read updated, more precise bar-code labels on inventory items. At the stores, workers use hand-held laser scanners to speed goods through Wal-Mart's automated receiving system, cutting labor by as much as 60 percent compared to manual freight handling, claims the company.

By next spring, Wal-Mart expects to have laser-scanning check-out counters in all its stores. Not only do lasers make check-out more efficient—a big plus for customers—but the scanning systems also let Wal-Mart update its inventory the instant goods leave the store. Captured in minicomputers tied to the scanners in each store, this data can be used for automatic reordering. More importantly, Wal-Mart uses the information to identify sales trends as they develop so stores can stock up on popular items.


Sam M. Walton
Chairman and CEO
ROB NELSON/PICTURE GROUP

Observers don't expect the company's passion for innovation to abate. Analyst Morris sees the retailer expanding nationwide by the end of the century, relying on technology to sustain growth both in new and established markets.

—Jeffrey Zygmont

THE RUNNER-UP: TOYS 'R' US

At Toys "R" Us, technology is far from child's play. "By using technology intelligently, we can lower the cost of operations and make it easier to shop in our stores," says Michael Goldstein, executive vice president and chief financial officer.

Toys "R" Us toy stores use scanning systems for speedier check-out and better inventory control. All of the company's 313 stores nationwide converted to the advanced system in just five months, and its 86 Kids "R" Us clothing outlets are scheduled to finish a similar switch to check-out scanners this month, after a four-month conversion program. "The company is very receptive to new systems—it instills that in the corporate culture," says Linda Morris, a retail analyst at Provident National Bank.

Nucor

Business writers might once have saved a lot of time by programming their word processors to type the phrase *dying steel industry* with one keystroke. During the darkest days, in 1986, steelmakers bled $4.2 billion in red ink, says the Washington-based American Iron and Steel Institute. The industry lacked the capital it needed for modernization, making it all but impossible to invest in the advanced technology that might rescue it.

Nucor has garnered widespread acclaim by climbing up the down escalator, making handsome profits while its competitors dodged bankruptcy. The company has made money every quarter since 1965, when present management took over; return on equity has exceeded 10 percent every year since 1982.

	1987	CHANGE FROM 1986
■ SALES	$851 million	+13%
■ PROFITS	50.5 million	+9%

■ TECHNOLOGY-USE STRATEGY
Aggressively adopts new methods of continuously casting steel in efficient "minimills" to enter the lucrative sheet-steel market.

■ Nucor
4425 Rondolph Rd.
Charlotte, NC 28211
(704) 366-7000

The secret? "We build plants economically and run them efficiently," says chairman and chief executive F. Kenneth Iverson, whom analysts hail as the sharpest steel man in America. "Iverson's good management has played a big part in Nucor's spectacular success," says industry watcher Walter Carter, vice president of Data Resources.

Much of Nucor's success springs from finding innovative, cheaper ways to make steel. Conventional plants convert iron ore to steel in blast furnaces. To run economically, the process needs large facilities with huge production capacities. Using such centrally located furnaces often means shipping raw materials and the finished steel long distances.

Nucor has pioneered the use of "minimills," smaller facilities that consume scrap metal, often available locally. They typically serve only regional customers, lowering shipping costs. Moreover, the company has built its mills in areas with weak unions, reducing labor costs.

The minimills use relatively efficient electric furnaces to melt the scrap into steel bars. To further boost efficiency, Nucor's mills cast steel in a continuous strand rather than in batches. A ladle pours molten steel through a nozzle into an adjustable mold that lets workers change the mold's dimensions as the steel flows through it. The operation is highly automated; in one minimill, six people control the entire process from the furnace to where the steel is cut for shipping.

Today's minimills make mainly steel bars, saving the capital cost of the equipment needed to roll the ingots into sheets. But there is an enormous demand for sheet steel, particularly in the automotive and appliance industries. Nucor will attack these markets by using even more advanced technology. One new mill will cast molten steel into pieces as thin as 1.5 inches, which can be rolled into sheets far less expensively than standard slabs. Nucor plans to turn out 800,000 tons a year.

The risk is enormous; thin-slab casting, developed in West Germany, has yet to be used on a commercial scale. Nucor's daring makes investors nervous—with good reason, analysts say. "They're going to lose millions of dollars at first, until these mills start producing," says Oppenheimer vice president John Tumazos. Still, Tumazos is won over by Nucor's past success in managing technology: "I'm recommending the stock, rolling the dice, and saying my prayers."

Larger steel producers are developing their own direct-casting techniques, but Nucor's early forays into the technology give it a three- to five-year head start over other steel companies, says analyst Douglas Moffat at Fahnestock. Nucor's financially strapped competitors don't have the wherewithal to modernize their plants to the degree that Nucor has, according to Moffat.

F. Kenneth Iverson
Chairman and CEO

BILL BALLENBERG

Nucor best not grow complacent. Preliminary figures indicate that the steel industry pulled itself back into the black in 1987 to post its first profitable year since 1981. With money once more in their coffers and Nucor's success as a model, big producers such as USX, Inland, and Bethlehem will surely crank up their technology spending.

—Herb Brody

THE RUNNER-UP: CARPENTER TECHNOLOGY

Carpenter Technology makes more than 400 grades of specialty steel, from the common stainless variety to nickel-based "superalloys" used in the aerospace industry. Consistent profits have enabled the company to invest in technology more heavily than its larger but financially ailing competitors. Since 1980, it has spent about $400 million modernizing its mills, according to president and chief operating officer Adolph Lena.

One Carpenter plant recently installed this country's largest rotary forge—an Austrian-built machine that makes billets and bars out of superalloys. At another mill, Carpenter spent $120 million for a computer-controlled rolling system. This mill is among the first to use induction heating to maintain even temperatures in the cast metal, assuring more uniform structure and better surface quality.

Federal Express

Federal Express Corp., the market leader in the overnight package-delivery business, is also the hands-down leader in taking advantage of technology. "Federal's technology is much more sophisticated than anyone else's in the industry," says David Guthrie, first vice president of research at Morgan Keegan & Co.

The question is, did Federal's technology efforts led to its market success, or vice versa? Analyst Mike Walker of Legg Mason says the company poured dollars into technology and communications because "they've been so profitable for so long they had the money to do it." But Raymond Mucci, director of research at Baird Patrick, credits the company's reputation for innovation as one of the main reasons for its success. Federal has a technology orientation—"a propensity to innovate," says Mucci—which derives from the influence of chairman, president, and chief executive Frederick W. Smith. "They took advantage of all the computer and technological aspects that were available to them," says Mucci.

	1987	CHANGE FROM 1986
SALES	$3.2 billion	+23.5%
PROFIT	–$66 million	–150%

TECHNOLOGY-USE STRATEGY
Uses leading-edge identification, communications, and data-processing equipment to provide superior customer service.

Federal Express
2005 Corp. Ave.
Memphis, TN
38132
(901) 369-3600

At the moment, attention centers on Federal's ground-breaking Cosmos information network, which tracks packages instead of the packages' paperwork.

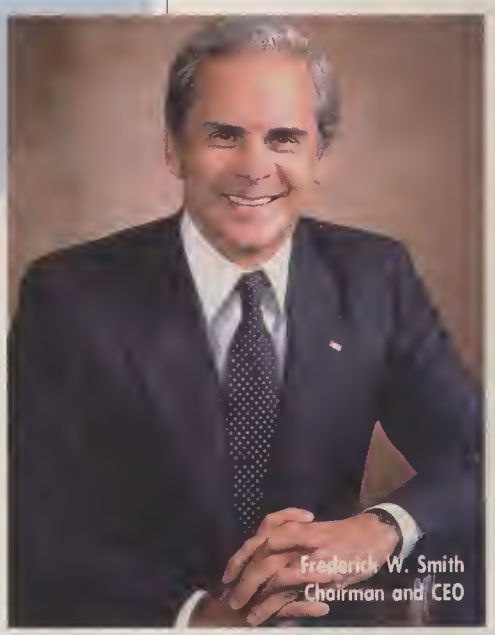
"In this business it's not enough to pick up and deliver on time. You have to provide information about high-priority packages to make customers feel comfortable," says Harry Dalton, Federal Express vice president of strategic integrated systems. As early as 1977, Federal experimented with a call center designed to handle requests for package pickups and information. Federal's 14 call centers now form the backbone of the Cosmos network.

To relay data to its trucks and local distribution stations, Federal replaced its overburdened radio system with a system called Digital Assisted Dispatching (DAD). Because DAD receivers store messages until the driver is ready to review them, drivers do not have to be in their trucks when pickup requests come in. Today, about 80 percent of Federal's volume is handled by DAD-equipped couriers, says Dalton.

Probably the greatest Cosmos innovation is door-to-door package tracking, a program that began in 1981 when Federal installed the automatic identification and communications equipment necessary to trace parcels between distribution stations. The major breakthrough, however, was giving each driver a hand-held laser scanner—a tiny computer incorporating both a scanner and a data-entry keypad. These scanners read bar-code tags attached to each parcel and feed information to the company's computer network.

Recognizing that the system's success hinged on the reliability of these scanners, Federal spent several years looking for a hand-held unit that could survive the rigors of field use. Last December, the company completed Phase I of the program, which involved tracking deliveries; Phase II—tracking pickups from the shipper's door—should be finished in May.

In addition to improving service, this system boosts productivity. For example, Cosmos data can be used to let distribution stations know how many packages are headed their way.


Frederick W. Smith
Chairman and CEO

Despite a long string of technology successes, Federal's record isn't perfect. Its stab at electronic mail, called ZapMail, proved an embarrassing failure; cancelling the project cost the company a $66-million net loss last year. But innovative technology has helped Federal's business by decreasing costs and allowing the company to offer the superior service that attracts customers. "You can't quantify that into earnings or market share, but it doesn't take much imagination to see the connection," says Guthrie of Morgan Keegan.

—Fredric Paul

THE RUNNER-UP: AMR

AMR Corp., the porent compony of American Airlines, has won industry-wide occlaim for its saphisticated reservotions system, called Sabre.

Sabre provides essential flight infarmation to about 38 percent of the nation's 27,000 travel agents, ond leads the morket for flight-informotion systems. In 1987, Sobre earned $107 million in 1987 operating profits on revenues of $405 million, excluding taxes and substontial capital investments in the system.

In oddition to selling Sobre to smaller airlines, AMR offers information generoted by the system to businesses outside the trovel industry. Individual and corporate clients con top into Sabre to book flights, reserve hotel rooms, and rent cors without having to go through a trovel agent. AMR olso operotes o reservation service for hotels and car-rental companies.

THE BEST AT PUTTING TECHNOLOGY TO WORK

HIGH TECHNOLOGY BUSINESS PICKS THE TOP 5 TECHNOLOGY USERS IN 10 KEY INDUSTRIES

The editors of HIGH TECHNOLOGY BUSINESS ronked the following companies in order of excellence at manoging technology. This honor roll is based on a survey of analysts and industry executives. We osked these experts to rate the 20 largest companies in each industry in terms of how well they harness technology to improve their operotions.

■ Aerospace and Defense

1. . . . . Martin Morietta, Bethesda, Md.
2. . . . . TRW, Clevelond
3. . . . . Northrop, Los Angeles
4. . . . . Lockheed, Colabasas, Calif.
5. . . . . Raytheon, Lexingtan, Moss.

Other companies considered: Allied-Signal, Boeing, Calt Industries, Fairchild, General Dynamics, Grummon, Litton, McDonnell Douglas, Parker-Hannifin, Rackwell International, Rohr Industries, Singer, Sundstrand, Textron

■ Computers and Electronics

1. . . . . Apple Computer, Cupertina, Calif.
2. . . . . Hewlett-Packard, Polo Alto, Calif.
3. . . . . Digital Equipment, Moynord, Mass.
4. . . . . International Business Machines, Armonk, N.Y.
5. . . . . Texas Instruments, Dallas

Other companies considered: AT&T, Control Data, Emerson Electric, Horris, Honeywell, ITT, Johnson Controls, Kidde, Motorola, Narth American Philips, NCR, Pitney Bowes, Unisys, Wang, Xerox

■ Financial Services

1. . . . . Citicorp, New Yark
2. . . . . American Express, New York
3. . . . . Security Pacific, Los Angeles
4. . . . . Merrill Lynch, New York
5. . . . . Cigna, Philadelphia

Other companies considered: Aetna Life & Casualty, BankAmerica, Bankers Trust New Yark, Chase Manhattan, Chemical New York, Federal Notional Martgage Associotion, First Boston, First Chicago, First Interstate Bancorp, Manufocturers Hanover, Mellan Bonk, J.P. Morgan, Saloman, Trovelers, Wells Farga

■ Food Processing

1. . . . . Archer Daniels Midland, Decatur, Ill.
2. . . . . Kellogg, Battle Creek, Mich.
3. . . . . Coca-Cola Enterprises, Atlanta
4. . . . . Anheuser-Busch, St. Lauis
5. . . . . A tie: H.J. Heinz, Pittsburgh, and Pepsico, Purchose, N.Y.

Other companies considered: Borden, Campbell Soup, ConAgra, CPC International, Generol Mills, IC Industries, Kraft, Pillsbury, Quaker Oats, Ralston Purina, Sara Lee, Staley Continental, Swift Independent, United Bronds

■ General Manufacturing

1. . . . . 3M, St. Paul, Minn.
2. . . . . Generol Electric, Foirfield, Cann.
3. . . . . Whirlpool, Benton Horbor, Mich.
4. . . . . Eastman Kodak, Rochester, N.Y.
5. . . . . TRW, Cleveland

Other companies considered: American Standard, Borg-Warner, Caterpillar, Chrysler, Dano, Deere & Co., Dresser Industries, Ford Motor, FMC, General Motors, Ingersoll-Rand, Navistar, Teledyne, United Technologies, Westinghouse Electric

■ Oil and Chemicals

1. . . . . Du Pont, Wilmington, Del.
2. . . . . Amoca, Chicogo
3. . . . . Exxon, New York
4. . . . . Dow Chemicol, Midland, Mich.
5. . . . . Chevran, San Francisco

Other companies considered: Ashlond Oil, Atlantic Richfield, Coastal, Mobil, Monsanto, Occidental Petroleum, Phillips Petroleum, Procter & Gamble, Shell Oil, Standard Oil, Sun, Tenneco, Texaco, Union Carbide, Unocal

■ Pharmaceuticals

1. . . . . Merck, Rahwoy, N.J.
2. . . . . Abbott Laboratories, Abbott Park, Ill.
3. . . . . Eli Lilly, Indianapolis
4. . . . . Schering-Plough, Madison, N.J.
5. . . . . Upjohn, Kalamazoo, Mich.

Other companies considered: American Home Products, C.R. Bard, Baxter Trovenol, Bectan Dickinson & Co., Bristol-Myers, Corter-Wallace, Johnson & Johnsan, Pfizer, A.H. Rabins, Rorer, SmithKline Beckman, Squibb, Sterling Drug, Syntex, Warner-Lambert

■ Retail

1. . . . . Wal-Mart Stores, Bentonville, Ark.
2. . . . . Toys "R" Us, Rochelle Park, N.J.
3. . . . . The Limited, Columbus, Ohio
4. . . . . Tandy, Fort Worth, Tex.
5. . . . . Price, San Diego

Other companies considered: Allied Stares, Corter Hawley Hole, Dayton Hudson, Federated Department Stores, F.W. Woolworth, J.C. Penney, K Mart, May Department Stores, Melville, Montgomery Ward, Revco, Seors Roebuck, Service Merchandise, Walgreen, Zoyre

■ Steel and Metals

1. . . . . Nucar, Chorlotte, N.C.
2. . . . . Carpenter Technology, Reading, Pa.
3. . . . . Inland Steel Industries, Chicago
4. . . . . Aluminum Co. of America, Pittsburgh
5. . . . . Worthington Industries, Columbus, Ohio

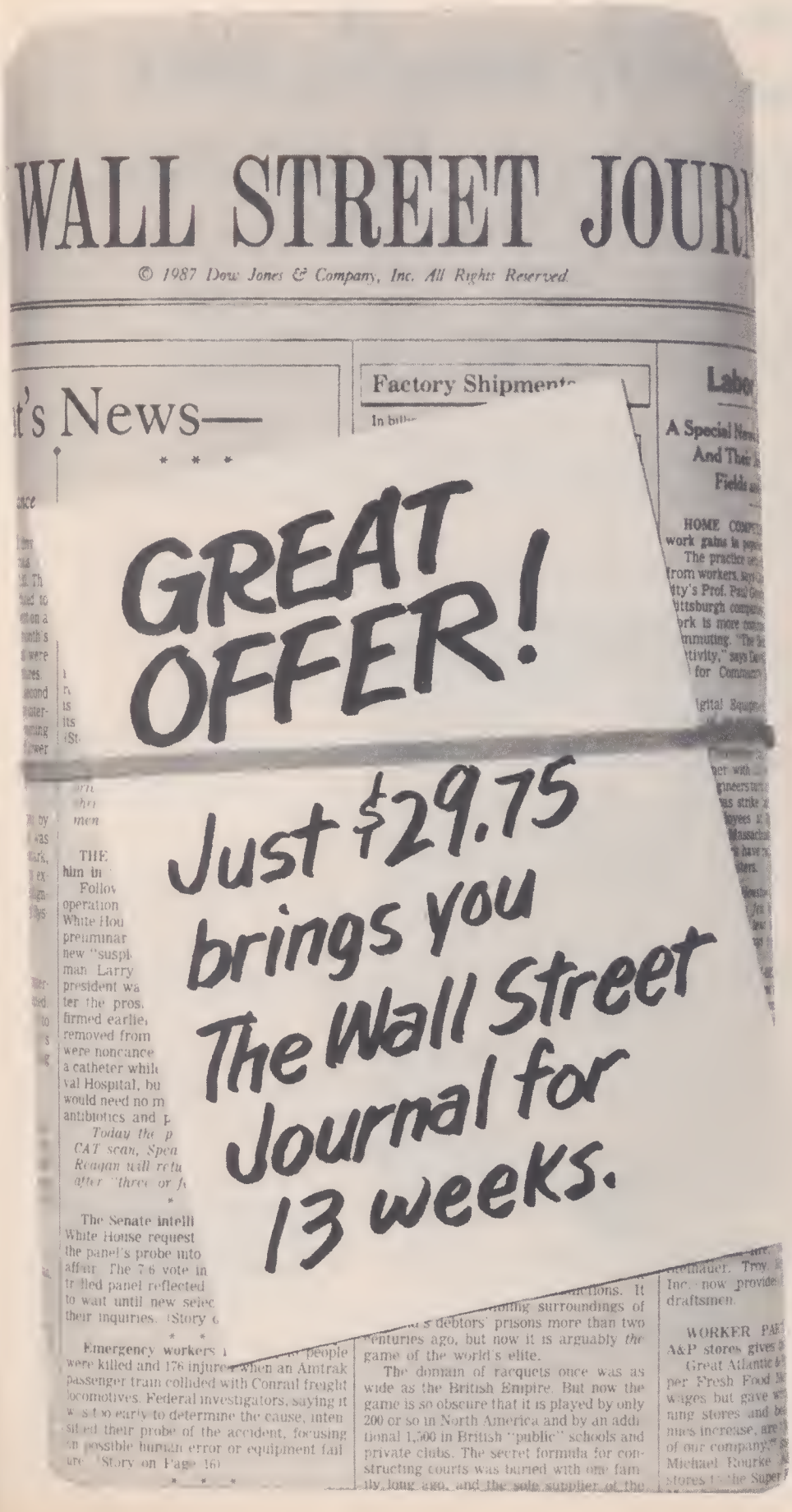
Other companies considered: Armco, Asarco, Bethlehem Steel, Cyclaps, Handy & Harman, H.H. Robertson, Koiser Aluminum, LTV, Newmont Mining, NVF, Phelps Dodge, Reynolds Metals, U.S. Steel, Weirton Steel, Wheeling-Pittsburg Steel

■ Transportation

1. . . . . Federal Express, Memphis, Tenn.
2. . . . . AMR, Dallas-Fort Worth Airport, Tex.
3. . . . . United Airlines, Chicago
4. . . . . Consolidoted Freightwoys, Palo Alto, Colif.
5. . . . . Delta Airlines, Atlanta

Other companies considered: Burlington Northern, CSX, Leasewoy Transpartation, Narfalk Southern, Northwest Airlines, Pan Am, Piedmont Aviation, Roadwoy Services, Santa Fe Southern Pocific, Texas Air, TransWorld Airlines, Union Pacific, United Porcel Service, US Air Group, Yellow Freight Systems

SOURCE: HIGH TECHNOLOGY BUSINESS RESEARCH



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MICHAEL KIENITZ

GE's Ron Kokot: Picturing more growth in MRI sales.

IN 1986, if a chronic headache sufferer checked into the hospital for an MRI scan—magnetic-resonance imaging—chances are the hospital used a scanner from Technicare. This company, then a division of Johnson & Johnson, had installed more of these scanners than anyone else in the business. Despite this lead in market share, Johnson & Johnson sold the division to General Electric Medical Systems that year. "We just weren't making a profit on the equipment," says a company spokesman.

Scenarios like this may recur as competition heats up in this small but lucrative market. Analysts insist that the MRI field, though growing, cannot sustain the current cast of about 25 manufacturers. Already GE Medical Systems has bulldozed two competitors, purchasing Thomson-CGR of France after Technicare, and analysts expect further consolidation.

Magnetic-resonance imaging is a technique for taking pictures of internal organs and body tissue, similar to X-ray images of bones. So far, price has been the major limit on the broader use of such scanners. GE and three of the four other major MRI manufacturers—who together accounted for 83 percent of last year's $710-million worldwide market—have concentrated on selling more powerful, and more expensive, systems. But last year GE, the clear leader with a 32 percent market share, introduced its MR Max, a mid-strength, lower-priced scanner. Such mid-level systems were already available from Siemens Medical Systems, Philips Medical Systems, and Picker International, companies that rank among the top five in the field. It all adds up to a battle to sell the lower-powered machines, which is where the market is expected to shift, at least temporarily.

Although that's good news for hospitals and medical groups that may now be able to afford an MRI scanner, it may spell disaster for the small companies that have sprung up with hopes of becoming low-end suppliers. Even the second-tier MRI manufacturers are at risk of being pushed aside or acquired by their larger rivals. The threatened companies include Fonar of Melville, N.Y., Metriflow of Milwaukee, Resonex of Sunnyvale, Calif., Bruker Instruments of Billerica, Mass., and Israel's Elscint. Only the top four companies will survive intact, says Terrance Gill, executive director of the Cooperative for MR Imaging, a consulting group. He expects some of these smaller outfits to merge.

Some smaller companies offer capabilities that surpass those of their larger rivals. Nevertheless, the larger players have more capital and more marketing savvy, and their broader product lines appeal to customers. The big guys can also help finance MRI machines, which start at about $1 million before installation and maintenance.

Magnetic-resonance imaging has been available since 1983, but it got its biggest boost when Medicare began paying for the procedure in 1985. Since then, MRI has become the fastest growing medical-imaging technology, seizing market share from CAT (computerized axial tomography) scanners and X-ray equipment. About 1,300 MRI units have been installed around the world, and the market could take at least 3,000 more, says medical-technology consultant Philip Drew. When the 4,000-unit saturation point is reached by 1995, he expects the yearly replacement market for improved systems to total about 600 machines.

To create an image, an MRI scanner generates a strong magnetic field around a patient, who usually lies on a table inside the pipeline-shaped device. The magnetic field attracts hydrogen protons in the body, aligning the protons parallel to the field. A technician scatters the protons by blasting them with a harmless radio wave. When the radio wave is turned off, the protons realign with the magnetic field. Their movement generates their own weak radio wave, which is detected by sensors in the MRI machine.

The sensor data goes to a computer, which constructs three-dimensional images of organs and soft tissue by assembling parallel scans that show "slices" of the body. Because protons are plentiful in fat and water but absent in bones, MRI scanners can see through bones to provide unobstructed views of the brain and spinal column.

New applications for MRI are being developed rapidly, such as spectroscopy—analysis of the body's chemical composition. Blood-flow imaging could replace angiography, a technique that requires the painful injection of dyes.

The most powerful MRI systems use superconducting magnets that have field strengths of 1 to 1.5 teslas (a tesla is the unit of measurement for magnetism). GE's MR Max and other mid-range devices generally operate at about 0.5 tesla. Some smaller companies sell systems with even weaker magnets. Thanks to software enhancements, low- and mid-field magnets can produce comparable images, though scanning can take longer than with more powerful machines.

Most of the MRI devices installed so far belong to teaching centers and major hospitals, which can afford the most expensive, cutting-edge technology. These early sales pushed the demand for more powerful systems. But the next wave of growth will come from medium-sized community hospitals with 150 to 300 beds, which have either been sharing MRI scanners with other hospitals or just not using them. "The first 1,000 were probably pretty easy to place," says Paul Brown, a medical-technology analyst with Hambrecht & Quist. However, today's shoppers are much more sensitive to price, he says.

This is the market the newer, smaller MRI suppliers had hoped to cultivate. The presence of larger, more established players will make that difficult. "When we advise clients about purchasing an MRI system, we consider local service and customer support," says Mark Johnson, vice president at consultant MD Buyline. "We look at corporate viability and stability. Will the company keep investments going in research and development, and will it be there in five years?" Such criteria usually favor larger, better established suppliers.

Because of the substantial investment involved, buyers are typically guided by the advice of consultants when shopping for MRI scanners. At least 700 of the 1,000 units installed in the United States were bought with the help of consulting firms such as MD Buyline, the Cooperative for MR Imaging, and Kenneth Johnson Associates.

MRI's high price also boosts the appeal of the financing offered by larger companies. GE's variety of financing and leasing plans often give it an edge, says Ronald Kokot, general manager of MR marketing at GE Medical Systems. Smaller companies such as Resonex can't afford such services, though financing is available through other sources. Kokot says that GE provides financing on 90 percent of its sales; more than 40 percent of its machines are leased.

Low-power scanners made by the smaller contenders offer advantages beyond their reasonable price. Even the mid-strength products of the major players rely on relatively powerful superconducting magnets that require expensive cooling systems. Such scanners also need extensive shielding to prevent interference with other electronic devices such as pacemakers and computer tapes and disks.

The bother of more powerful machines is probably not worth it for some MRI uses, so systems from companies such as Fonar and Resonex that rely on less troublesome resistive and permanent magnets may find comfortable niches. "As the field matures, people won't look for a single unit to meet all their purposes," says Fonar's Anthony Giambavlo, senior vice president for research and development. Hospitals may use both low-power and high-power units. Giambavlo points out that smaller devices can pay for themselves in

LEADING MRI MAKERS

COMPANY	MRI MAGNET TYPE(S)	INNOVATION
Diasonics MRI 280 Utah Ave. S. San Francisco, CA 94080 (800) 468-4400	0.35 tesla	"Open air" MRI system, awaiting FDA approval
GE Medical Systems Box 414, Mail Code W439 Milwaukee, WI 53201 (414) 544-3721	0.5 and 1.5 teslo	Fast scanning, to be introduced in 1988
[illegible]	[illegible]	[illegible]
Picker International 595 Miner Rd. Highlond Heights, OH 44143 (216) 473-3000	0.5, 1.0, and 1.5 teslo	New method to reduce motion blurs in imoges
Siemens Medical Systems 186 Wood Ave. South Iselin, NJ 08830 (201) 321-3020	1.0 and 1.5 tesla	Enhanced blood-flow imaging, to be introduced in 1989

SOURCE: HIGH TECHNOLOGY BUSINESS RESEARCH

four months if used on five or six patients a day, a fact that may make such systems attractive for specialized work such as spine and head imaging. So far, Fonar has sold 110 systems.

As part of this trend, Metriflow is developing scanners to take pictures of arms or legs instead of the whole body, creating cheaper but efficient systems.

This type of niche marketing has paid off for Diasonics, the only company among the top five that doesn't offer an MRI system with a high-field-strength magnet. The $268-million company, which gets about 40 percent of its revenues from MRI, has garnered 14 percent of the market, partly by focusing on mobile MRI systems that travel from hospital to hospital in a van. Thus, several medical centers can share the expense of buying and operating a scanner. The mobile market will account for 30 to 50 percent of MRI sales in the next two years, according to Suzanna Pribyl, head of technology and policy planning at the American Hospital Association.

To maintain its grip on the market, some analysts expect Diasonics to link up with another MRI manufacturer, which would supply higher-field-strength units for Diasonics to sell on the U.S. market. Jean Kenton, an analyst at Market Intelligence Research Corp., speculates that this partnership may involve Japan's Toshiba, which accounts for 4 percent of the worldwide market and is the dominant player in Japan. Toshiba has already licensed Diasonics' technology for sale in Japan.

Another small company, Advanced NMR Systems of Woburn, Mass., is mining gold in magnetic-resonance imaging by addressing a major drawback of the technology: slow operating speed. A typical scanner takes several minutes to process an image, and this limits the number of patients it can scan. Also, moving organs such as the heart cause blurred pictures, as does respiration.

The company's Instascan scanner uses a modified system to create a stronger magnetic field. This lets the machine capture scans at 1/25th of a second, many times faster than the time conventional systems need to capture an image. Instascan also captures its data in just one scan, instead of the hundreds of scans taken by other machines. This one scan essentially freezes the motion of moving organs, says Richard R. Rzedzian, the company's chief scientific officer.

Advanced NMR has agreed to sell Instascan hardware and software packages to General Electric Medical Systems. Beginning late this year, GE will offer the software as an option on its Signa 1.5-tesla MRI scanner. With the backing of market leader GE, Instascan could mean annual revenues of $10 million for Advanced NMR. The company will also sell MRI systems on its own, and has an agreement for its first one—a $2-million unit for the Yale University School of Medicine.

While the small and medium-sized contenders dig into niches, forays by large companies into mid-range MRI machines are so far meeting only mixed success. Siemens, for instance, abandoned its scaled-down MRI scanners last year. "We only sold two in 1987," says MRI marketing manager Thomas Miller, "and we sold 35 with 1.5-tesla magnets."

For the long term, Siemens' decision seems reasonable. Most analysts doubt that machines with magnets weaker than 1 tesla will be able to handle such new wrinkles as spectroscopy, so many hospitals will probably buy 1.5-tesla devices with superconducting magnets from the major suppliers who have the resources to offer upgrade packages. One analyst says that GE purchased Technicare for the opportunity to replace or upgrade the 300 units that had already been sold.

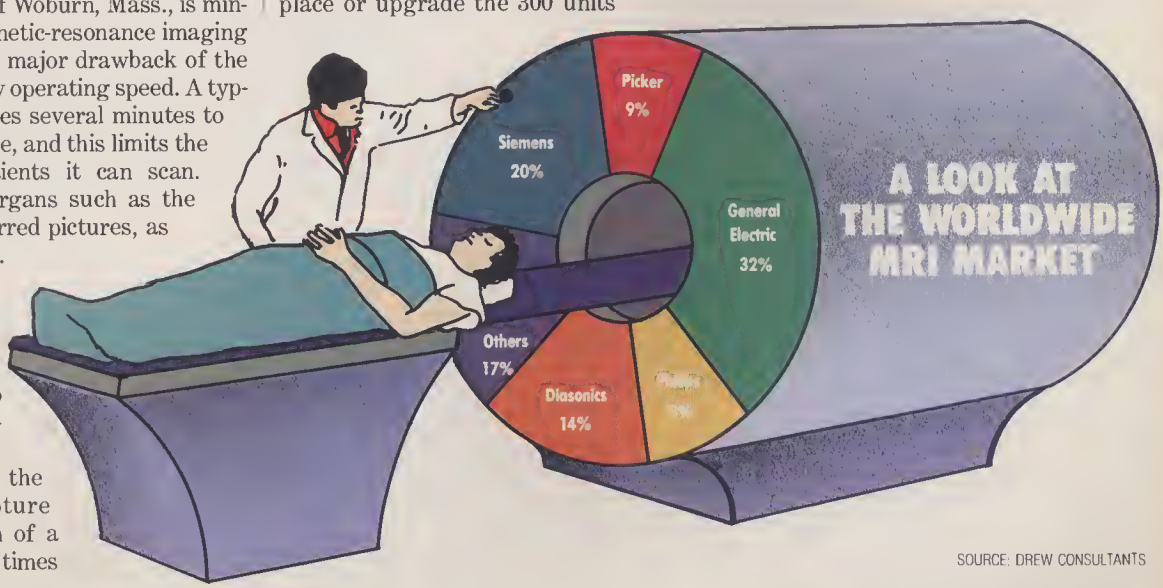
One of the biggest problems for the leading MRI contenders has been product similarity. For example, Philips and Picker had planned to merge their lines to offer a broader range of products. But the deal was cancelled, presumably because the two companies found that their product lines were too much alike, according to analysts.

Similarly, analysts assume that differentiation was a key motive behind GE's licensing of MRI software from Advanced NMR Systems. The Instascan system will give GE's Signa 1.5-tesla scanners much faster performance. Other acquisitions may also be on the way; Metriflow could be a prime target because of its unique product—small MRI devices for producing images of specific parts of the body.

But problems of product differentiation aren't crippling. Market share continues to move toward the five established players. For the companies that survive the shakeout, the pot may be bigger than current forecasts portend. At least that's the word from some of the people who use MRI scanners.

"We'll see it used increasingly for diagnosing the stages of cancer, and it will compete with fast CAT scanning for patients with coronary-artery disease," says Dr. James Thrall, radiologist-in-chief at Massachusetts General Hospital. From a clinician's point of view, Dr. Thrall sees high demand for MRI scanners. "Every prediction we have made has undervalued the need," he says. ■

MICHAEL ULLRICH



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Mobile Phones Move From Cars To Pockets

Hand-held portable telephones will eventually rule the market

BY FREDRIC PAUL

SAY GOODBYE to the car phone. Portable telephones, some of them small enough to fit in a pocket, will carry cellular service into the future.

Though the first cellular radio telephone system started only five years ago in Chicago, there are now more than a million cellular phones in use in the United States, and that number is expected to more than double by 1990. By then, analysts say, a significant number of those phones will be in callers' hands, not in cars.

Portable telephones are "growing like stinkweed," says Bob Miller, vice president of merchandising for consumer products at Radio Shack. "Eventually," he says, "there won't be anything but portables."

Observers say portable telephones will open up a new range of uses. As companies develop smaller, cheaper, and better-performing models, cellular telephony will change from a niche industry supplying well-wheeled executives to a mass-market consumer item. Eventually, tiny cellular phones with desk-phone prices may render pagers, pay phones, and telephone answering machines obsolete.

But the change won't come overnight. Although top industry executives began praising portables as early as 1982, even the most optimistic forecasts say the transition to portable telephones won't be in full swing until the mid-1990s, at the earliest.

It may take a while to build up a head of steam, but the trend toward portable phones is already rolling. Sales of transportable cellular phones—units about the size of a briefcase—have risen steadily, and truly portable phones, about the size of a walkie-talkie, have become a hot item this year. Calling 1988 "the year of the portable," Brad Sabako, a California-based regional sales manager for Finnish cellular-phone maker Nokia-Mobira Inc., says there is "a growing customer awareness that this is the best way to have a phone." Sabako says that the Scandinavian market is six or seven years ahead of the U.S. market, and that portable phones have grown from 5 to 40 percent of the market there.

1 9 8 7 PORTABLE-PHONE MARKET

NEC	28.4%
Motorola	24.6%
Mitsubishi	23.4%
Technophone	11.6%
OKI	7.9%
Other	4.3%

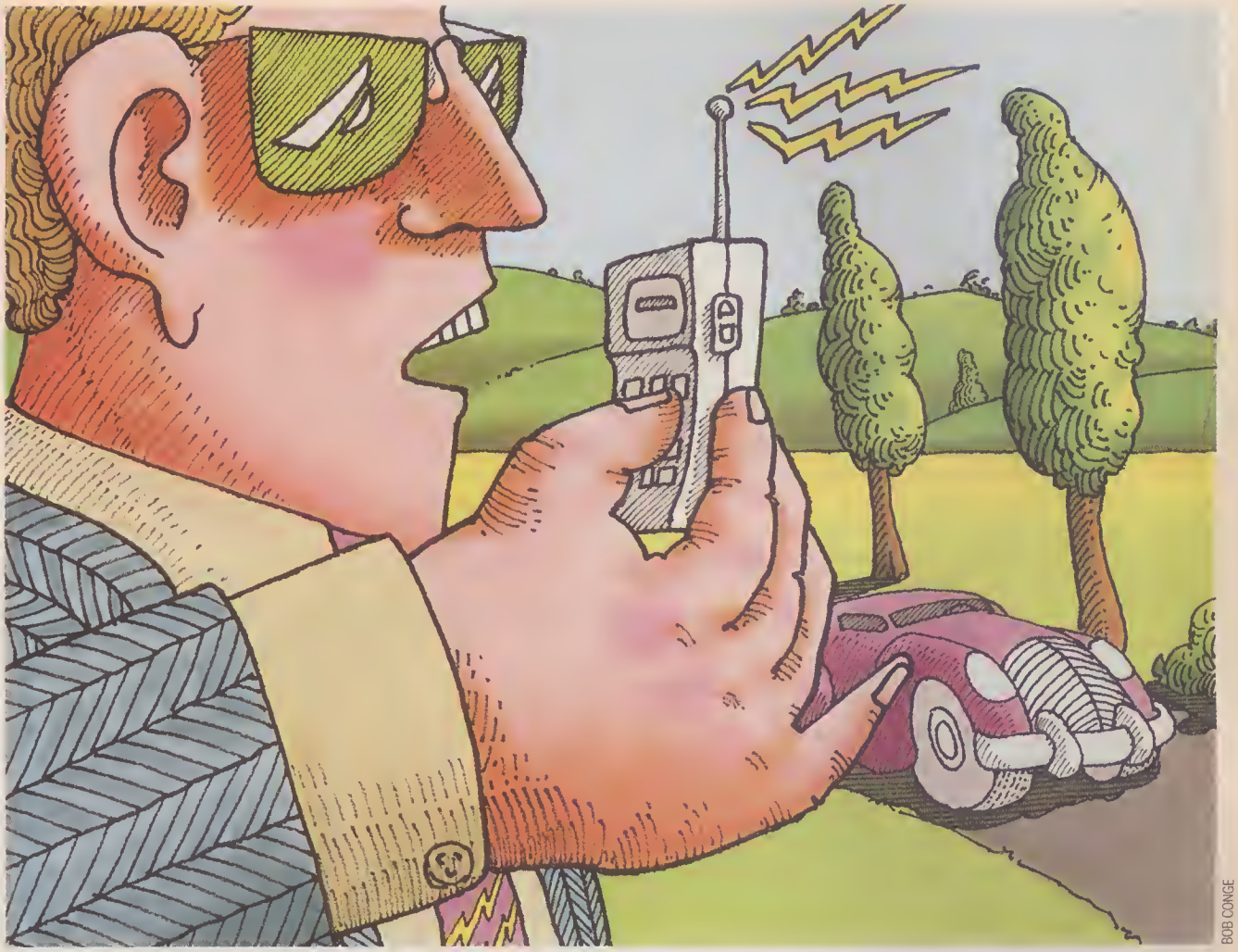
Retail only; Motorola leads when direct sales are included. (Totals over 100% due to rounding.)

SOURCE: HERSCHEL SHOSTECK ASSOCIATES

Portable-phone sales in the U.S. could triple this year, becoming about 10 percent of the total, says Herschel Shosteck, president of Herschel Shosteck Associates Ltd., a consulting and market-research firm. Other estimates put the portable-phone market share at an even higher level.

Two factors hold back portables: their relatively high price and the fact that they do not work well in all cellular systems. Portable phones generally provide just over half a watt of transmission power, compared to the three watts of car phones and transportable units. In top markets such as New York and Los Angeles, factors such as heavy volume, large geographic areas, and difficult terrain make service problematic even for car phones. In these markets, portable phones may be unusable, and have minimal market share.

Portable phones work much better in other major cities, including Chicago, Boston, and Washington. Hand-held units account for more than 60 percent of the market in Las Vegas, for exam-



BOB CONGE

ple, where the cellular system was designed expressly for portable phones. Charles F. Wright, vice president of operations for Centel Cellular Co., which operates a cellular system in that area, told attendees at a meeting of the Cellular Telephone Industries Association earlier this year, "In Las Vegas, cellular phones are perceived as being portables." Wright predicts portable phones will soon average 30 percent of the entire cellular market.

James P. Calle, director of marketing for the cellular subscriber division of Motorola Inc.'s Cellular Group, is even more optimistic. Calle expects portable phones to represent half of the entire cellular business by 1990. "Portable phones will be the product of choice," he says, "because they offer more utility" than do mobile phones.

"To a great extent, portables will be a terrific market for cellular manufacturers," says Scott Goldman, president of mobile communications specialist Goldman Group. Those manufacturers have fought a price war in the car-phone market, he says, but have kept prices for hand-held units relatively stable.

Premium prices equal strong margins—one reason why portable telephones are popular with manufacturers as well as with agents and retailers. Another reason is that portable phones need no installation, which helps erase the price differences between portable and car-phone models.

Among portable-phone makers, most of whom also make car phones, the early lead has gone to the pioneers. Motorola introduced the first portable phone when cellular systems first appeared, and remains the clear leader in cellular phones, both mobile and portable. However, Motorola faces increasing competition as more and more companies enter the portable business.

NEC America Inc., the U.S. arm of Japan's NEC, claims to have garnered one-third of the U.S. portable cellular market. The company attributes a chunk of those sales to a hand-held model that can be plugged into a car and used as a mobile phone. Products from Motorola and Mitsubishi also offer this capability, and Radio Shack's Miller calls it a trend. "Eventually, the size of the products will be the same," he says, "so why mount it permanently in a car? In five years, large trunk-mounted units will disappear."

Portable telephones have been good to Radio Shack. The company's new model, introduced late last summer, retails for less than $1,500, which the company claims is the lowest price around. Miller calls the product the company's "newest and biggest seller." With no installation headaches, portable phones play to Radio Shack's retail strength. "You don't have to go to a communications company for something you carry in your pocket," says Miller.

Japan's Oki Telecom, on the other hand, missed an opportunity by arriv-

ing late to the portable party, says Goldman. Oki has been a premier player in mobile phones for years, helping to set up the first commercial trials, but the company introduced its first portable model only recently. Goldman says Oki lost the chance to nab lucrative exclusive marketing agreements with agents and distributors, and also the chance to build brand loyalty.

While acknowledging that his company was late to the market when it introduced its CDL 300 portable phone a year ago, Oki Telecom's vice president of sales and marketing Woody Brooks maintains that "the portable market has been very good for us. I don't believe we lost anything."

Other problems have also dogged portable-phone companies. For instance, Technophone's early portable unit garnered bad publicity when the private-labeller announced it before Technophone could deliver sufficient quantities, says Technophone technical manager Sunny Shum. Today, says Shum, Technophone distributes an improved version under its own name.

According to Shosteck, sales depend on falling prices, and he says the falling dollar has prevented portable-phone prices from falling as fast as those of mobile phones. The average portable still costs almost twice as much as a car phone. But Radio Shack's $1,500 model isn't far from the average $1,200 cost of an installed car phone.

As more players enter the market, competition will push prices down, and Shosteck predicts a major price break this year. As capacity builds, he says, an oversupply could develop, possibly causing a price crash similar to the one that hit mobile phones in 1984.

Other factors influencing the future of portable telephones include better provisions for "roaming," or using the phones outside their home system, and further reductions in the size of portable cellular units.

"The real issue is battery technology," says Calle of Motorola. Portable phones need relatively large batteries, forcing manufacturers to strike balances between size, weight, power, and "talk time." In general, smaller units let users talk for shorter periods of time before having to change batteries.

Portable-phone makers are counting on new hydrogen, nickel, and lithium batteries, as well as on paper and plastic electrolytes, to help solve the power problem. With better batteries, porta-

MAKERS OF HAND-HELD PORTABLE PHONES

COMPANY	PRODUCT	PRICE	INTRODUCTION
Hitachi Sales of America 401 W. Artesia Blvd. Compton, CA 90220 (800) 262-1502	CR-2111 H; can register with two cellular services to avoid extra charges; weighs just 1.3 pounds	$3,000	January 1988
Mitsubishi Electric 800 N. Beirmann Ct. Mount Prospect, IL 60056 (312) 298-9223	DiamondTel 90X; car adapter available; also sold by General Electric	$2,195	June 1988
Motorola 1301 E. Algonquin Rd., SH4 Schaumburg, IL 60196 (312) 397-5000	Model 9500XL, an improved version of Model 8000X, which was the first portable, introduced in 1984; car adapter available	$3,295	November 1987
NEC America Mobile Radio Division 4910 W. Rosecrans Ave. Hawthorne, CA 90250 (213) 973-2071	P9000 Series; the P9010 and P9030 have car-adapter kits that boost power to 3 watts	$2,295	July 1987
Nokia Mobira 2300 Tall Pines Dr. Largo, FL 34641 (813) 536-5553	Mobira 500 Series; has car-adapter kit	NA	Due July 1988
Novatel 1020 64th Ave. N.E. Calgary, Alberta, Canada T2E 7V8 (403) 295-4500	Not yet named; claims to be the first 832-channel phone	NA	Due mid-1988
Oki Telecom Cellular Telephone Division 22-08 Route 208 Fair Lawn, NJ 07410 (404) 925-9200	CDL-350	$2,295	August 1987
Radio Shack 1700 One Tandy Center Fort Worth, TX 76102 (817) 390-3011	CT-300, the least expensive on the market	$1,499	August 1987
Technophone 255 Executive Dr. Plainview, NY 11803 (516) 576-2000	PC 105, the smallest and lightest on the market at 16 ounces; built in Britain by Technophone Ltd.; also sold by Audiovox and Repco	$2,020	March 1986

SOURCE: HIGH TECHNOLOGY BUSINESS RESEARCH

DIGITAL TECHNOLOGY KEY TO GROWTH

Even without the growth of portable telephones, the cellular industry is booming. That's good for profits, but as subscribers sign up more quickly than expected, many cellular systems will soon reach capacity.

To meet increasing demand—and expand the market beyond its initial base of 5 to 10 million potential subscribers—cellular carriers are expected to convert from analog to digital systems, which boost capacity by combining several conversations on one channel. Systems now under development can fit three to eight digital conversations in the bandwidth required by one analog signal. But by the early 1990s, advanced digital systems will raise capacity 10 times while cutting carrier costs by 75 percent, predicts Chris J. Bussey, director of product-line management at Northern Telecom of Nashville, Tenn. He says a 100-fold increase in capacity is possible by the year 2000.

Unlike analog systems, digital systems offer economies of scale. To add capacity by going digital, carriers need only replace channel racks and modify switch software; boosting analog capacity means installing expensive new cell sites, transmission towers, equipment sheds, microwave links, and leased telephone lines.

Hoping to get a head start, AT&T and Ameritech have begun demonstrating a digital system in Chicago that would triple the number of subscribers on each channel. But European companies, the traditional leaders in cellular development, have already committed themselves to building a Pan-European digital cellular network with a capacity for 10 million subscribers by the end of the 1980s. This system is expected to cost $1.3 billion in its first phase and serve about 15 million subscribers by the year 2000.

Major European companies involved in the first phase include France's Alcatel along with Germany's AEG and Finland's Nokia; Sweden's L.M. Ericsson in partnership with Germany's Siemens AG, France's Matra Group, and Britain's Plessey and Racal Electronics; and Holland's Philips working with AT&T and Germany's Bosch.

In the United States, observers say digital conversions will begin between 1989 and 1991, with the largest markets all-digital by 1995. Companies working on digital prototypes for the U.S. market include AT&T, Northern Telecom, and Motorola, as well as many of the European suppliers.

ble phones the size of credit cards and even wristwatches may be possible by the turn of the century.

In the near term, the use of large-scale-integration semiconductor devices, which pack dozens of circuits onto a chip, and surface-mount technology, which squeezes more chips onto a board, is helping to make portable telephones smaller and lighter. Hinting at this trend, Canada's Novatel Communications Ltd. will soon introduce a portable phone that is one-third smaller and one-third lighter than the $2,200 unit it has sold for the past 18 months, says Novatel spokesman Bob Betteridge.

While telephone makers push the smaller phones, many cellular carriers are worried that they will have to modify their networks to accommodate portable phones. According to Centel's Wright, portable units work poorly in areas of high population density because carriers can't afford to build enough cells to handle all the demand. "You can't justify a cell site on every corner," he says, so new cellular systems must be designed with portable phones in mind.

But even though portables don't have as much power as mobile units, properly designed systems should operate just as well with portables as they do with car phones, says Robert M. Carlson, vice president of switching-product management at AT&T Network Systems, which makes cellular equipment.

Another potential headache for cellular companies is the need to beam cellular signals into buildings to ensure continuous coverage, warns William C.Y. Lee, vice president of technology and planning at PacTel Cellular Co. of Irvine, Calif. He says PacTel has found that most portable phones are used indoors rather than on the street.

Despite the headaches, Carlson says carriers have no choice. "In the future," he says, "an awful lot of growth will come from portables."

Capacity concerns already have cellular carriers mapping changes to their systems. One improvement being eyed is digital cellular technology (see "Digital Technology Key to Growth," above). Such systems, under development in Europe and proposed for the United States, could create opportunities for carriers to meet the needs of portable phones while expanding capacity.

Digital systems will help the industry "metamorphose from car phones to personal mobile telecommunications," according to Gordon Crawford, senior vice president at Capital Guardian Research. "Digital portable telephones will be to cellular what HBO was to cable TV," he says.

Motorola's Calle adds that, despite technical challenges, portable phones are good for system operators because they promote greater system use. "It's a proven fact that people who use portables use them more and longer than people who use mobile phones," says market researcher Goldman.

But John DeFeo, president of U.S. West's NewVector Group in Bellevue, Wash., challenges that perception. "In our experience," he says, "portable phones use about as much air time as mobile phones." DeFeo, whose group runs several cellular systems, blames battery limitations on talk time for keeping down the use of portables.

Goldman, however, says current batteries on portables can provide as much as 45 minutes of talk time, far beyond the average cellular use of 10 to 12 minutes a day.

Ultimately, explosive sales of cellular phones will come only from the consumer market. So far, however, the consumer market has been almost too small to track, consisting only of a few affluent buyers using the phones as security devices for the family car. Motorola's Calle says a consumer breakthrough is still a long way off. In the consumer market, "the price of the phone is moot; the price of service is the key," he says, adding that he doesn't expect monthly cellular-service costs to come down significantly in the foreseeable future.

Still, the industry is confident that portable cellular phones will take off in the consumer market. It's only a matter of time. ■

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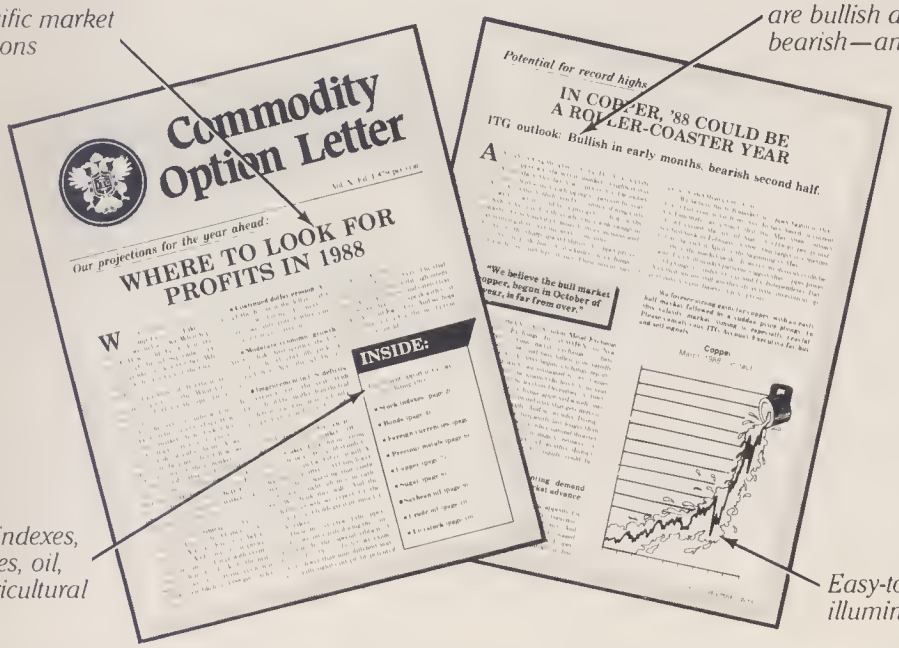

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Lottery Machines: Betting on Overseas Success

Little GTech owns most of the market for on-line lottery systems, but faces tougher odds in foreign sales

BY RANDY ROSS

AFTER THE devastating earthquake in 1985, one communication system was still working in Mexico City: a computerized network for buying lottery tickets. Supplied by the U.S. company GTech, the lottery system used radio transmitters to send bets made around the city to a central computer. GTech designed the system to overcome Mexico's unreliable telephone links—the usual means of connecting on-line lottery terminals. It seems the network more than measured up.

The system's survival illustrates the technological tenacity that has made GTech the tiny giant in on-line lottery systems. The $129-million-per-year public company does nothing but sell lottery systems and owns almost 70 percent of the world market, beating out such larger players as Control Data Corp., Bally Corp., General Instrument, and BCE Inc. (formerly Bell Canada Enterprises). But as U.S. sales decline, GTech will face stiffer challenges for overseas markets such as Europe and Latin America.

BILL O'CONNELL

■ **President Guy Snowden relies on overseas experience to keep GTech on top of the on-line lottery business.**

So far, most of the business for computerized lottery networks has been in the United States. But the domestic market is maturing. About 23 states have on-line lottery systems. Analysts expect about three more states to buy on-line technology each year for the next five years, but that doesn't match the rapid growth the industry experienced during the last five years. Analysts expect increasing competition to cut into profits, possibly forcing some players from the domestic market.

However, of the approximately 150 lotteries worldwide, only about 25 percent are already on line, estimates Cato Carpenter, an analyst at Alex Brown & Sons. The untapped market is estimated at about $3.75 billion, or about 10 times the size of the U.S. market.

Foreign countries are a natural for U.S. lottery technology. In many places, lotteries have existed in one form or another for at least 500 years and represent a

TOP LOTTERY-MACHINE MAKERS

COMPANY	MAJOR BUSINESS	1987 REVENUES	ON-LINE REVENUES
Bally/Scientific Games 3101 Tower Creek Parkway Atlanta, GA 30339 (404) 984-7777	Makes on-line transaction-processing systems for lotteries and other gaming operations.	$1.7 billion (Bally)	$85 million (5 percent)
BCE/British-American Banknote 150 Bloor St. West Toronto, Ontario Canada M5S 2X9 (416) 922-1122	Prints security-sensitive documents such as lottery tickets, currency, and passports.	$11.7 billion (BCE)	$9.7 million (less than 1 percent)
Control Data/Automated Wagering 142 West 57th St. New York, NY 10019 (212) 887-1652	Makes on-line transaction-processing systems for lotteries and other wagering operations.	$3.4 billion (Control Data)	$80-$90 million (2-3 percent)
General Instrument/Amtote 11126 McCormack Rd. Hunt Valley, MD 21031 (301) 771-8700	Makes on-line processing systems for lotteries and other wagering operations.	$1.1 billion (General Instrument)	$15-$20 million (1-2 percent)
GTech 101 Dyer St. Providence, RI 02903 (401) 273-7700	Makes agent/player-operated terminals and on-line lottery systems.	$129 million	$129 million (100 percent)
International Totalizator Systems 11095 Flintkote Ave. San Diego, CA 92121 (619) 931-4000	Makes on-line transaction systems for lotteries and other wagering operations.	$71 million	$25 million (35 percent)
Syntech International 4955 Energy Way Reno, NV 89502 (702) 329-6969	Designs and manufactures on-line processing and player-activated systems for lotteries.	$19 million	$19 million (100 percent)

SOURCE: HIGH TECHNOLOGY BUSINESS RESEARCH

significant source of revenue for many countries, provinces, and cities. In the U.S. alone, lotteries generated about $12.5 billion in gross revenues in 1987, and have been proposed as a solution to the federal budget deficit.

Because they process bets faster, computerized systems make more money than the slower, noncomputerized methods used in many countries. In the popular and lucrative lotto-type game, players pick their own number when they buy a ticket, and all those numbers must be recorded in a central database before the drawing. This process takes time in a manual system, which usually records the numbers in batches. On-line systems use super-minicomputers connected to each ticket outlet, which may be either a tended or self-service booth. Such systems record each number within four seconds after the ticket is requested, says Gary Gassin of technology think-tank Battelle Institute. This fast action allows ticket sales right up to drawing time, so more people can enter. The more people who play, the higher the payoff—and the higher the revenues for the lottery's sponsor.

That's advantage enough to lure many foreign lottery sponsors to purchase on-line systems, despite price tags as high as $15 million for a 1,000-terminal system. Supporting the system takes another $4.5 to $5 million annually, but a lottery sponsor can cover its yearly operating cost in the first five weeks, says Don Stanford, senior vice president of technology at GTech.

The question is, can GTech continue to roll sevens in the face of stiffer competition? The market leader won't win any more contracts based on technological superiority alone. The major contenders are about equal in their technological offerings, says Gassin, and thus join the foreign game with even odds.

Analysts say domestic performance is a good indicator of which companies will have the most luck playing the overseas market. Another important factor is knowledge of international business. Based on these criteria, Control Data's Automated Wagering Division is probably the best equipped to challenge GTech. The division's 1987 worldwide sales of on-line lottery systems, estimated at $80 million to $90 million, puts it in second place behind GTech's $129 million. Moreover, parent company Control Data, a $3-billion international computer company, can muster considerable resources; it spent an estimated $87 million to develop its newest on-line lottery system.

But Automated Wagering hasn't been without problems. To stave off creditors in 1985 and 1986, Control Data nearly sold the profitable division; however, Control Data side-stepped bankruptcy and business is back on track. "They just won the Florida lottery business, which is significant," says analyst Frederic Wise of Bear Stearns. Florida was one of the largest remaining states to go on line, and the account will bring the division about $130 million over the next five years. GTech was among the suppliers competing for the account.

Automated Wagering expects to pen a significant deal in the foreign on-line market, perhaps even by this year, says Marcel Helou, the division's vice president of sales. He says success overseas could double the division's on-line lottery revenues.

Parental support will be critical to Automated Wagering's foreign success. Control Data operates computer manufacturing and support services in about 25 countries around the world, says Peter Rae, director of marketing-support services. Further, Control Data owns Arbitron, a large market-research firm. Market research has proven critical in increasing lottery revenues through advertising and promotion. Arbitron can offer the demographic research needed for successful lottery programs; this combination of Control Data's capabilities helped secure the Florida contract.

Bally's Scientific Games division may also benefit from the resources of its parent, and also from Bally's reputation in the gaming industry. The company will win its first overseas on-line contract this year, predicts Thomas Little, the division's international sales manager. "We are bidding on contracts with seven European countries and talking with Japan," he says. Bally's involvement in about 20 instant scratch-off lottery setups gives it an in with many lottery sponsors.

Success in on-line lottery sales is important to Bally. Although such sales represent only about 5 percent of the company's total revenues of $1.7 billion,

international exposure for Scientific Games could be an admission ticket for Bally's other gambling businesses, says analyst Dan Lee of Drexel Burnham Lambert. Once governments get accustomed to lottery revenues, Lee says, they may eventually look for other gaming options such as slot machines, a Bally specialty.

Another player on the move is General Instrument, whose Amtote division was the first to offer an on-line lottery system, in 1975. Amtote has been making headway against GTech in the domestic market; it recently beat out GTech for a $40-million account in Connecticut and a smaller one in Quebec. The division also has some small accounts overseas. It operates a semiautomated system in Israel that circumvents weak phone systems by storing lottery bets on a diskette for later transfer to the central computer. "The foreign market is very important to us, and we are pursuing it vigorously," says William Weglein, marketing-support manager for General Instrument.

British-American Banknote, a division of $11.7-billion BCE, recently jumped into the computerized-lottery game and is expected to be a formidable player; the division has already won part of Quebec's lotto account. British-American Banknote has a 17-year track record selling instant tickets, according to Drexel Burnham Lambert analyst Robert Herz, plus the reputation and expertise of BCE, one of the largest suppliers of telecommunications and networking equipment in the world.

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Despite many strengths, the larger of the challengers have not been selling on-line lottery systems as long or as intensely as GTech has.

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The division also has a unique advantage because it prints currency for several potential on-line customers, says Marshall Pollack, president of British-American Banknote's lottery group. Because security and reliability are important considerations in selecting an on-line system, a country's currency supplier could be considered a good choice.

Several smaller companies, both American and foreign, also expect to benefit from the expanding international market. One of these is International Totalizator Systems, a $25-million U.S. company specializing in computerized gaming equipment, including systems for on-line lotteries, horse-racing, and casinos. This company focuses strictly on overseas business, and analysts expect good performance because of its 10 years of experience in operating overseas. In May 1987, International Totalizator went on-line in New South Wales, Australia, and has signed a $10-million deal in Malaysia. The company also has sales offices in Norway and Singapore.

Another player in the wings is Syntech International, which recently lost its only U.S. on-line account to GTech. Syntech is about a year away from really pushing for overseas business, says chief executive Gordon Graves. The company is establishing a niche in the United States selling player-activated terminals for self-service ticket sales.

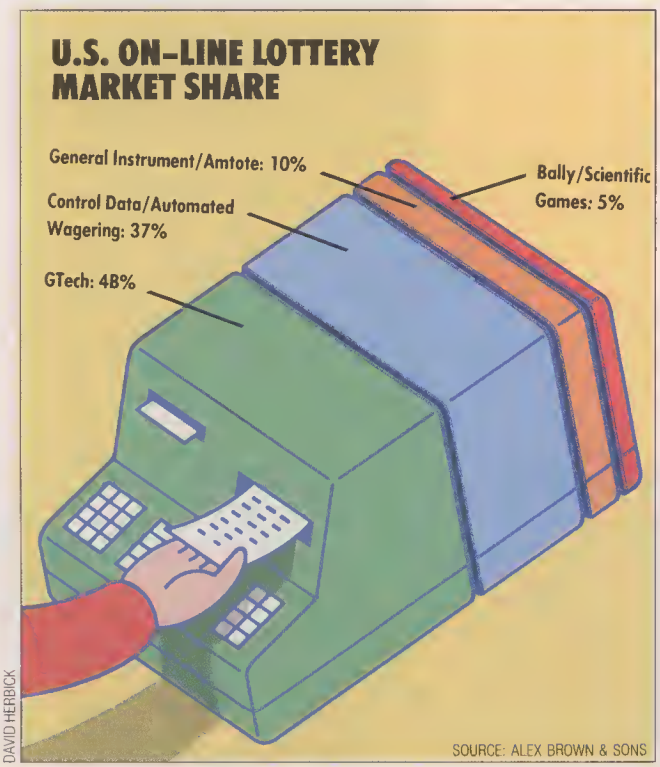
But GTech remains the company to beat. It too has valuable experience overseas—its first foreign account dates back to 1982, when it set up a system in Australia, recalls GTech president Guy Snowden. In addition to Mexico City, GTech has sold its earthquake-proven radio system to lottery sponsors in Venezuela and Spain.

Most importantly, analysts expect GTech to nose out its challengers because it has the most experience. Despite many strengths, the larger of the challengers have not been selling on-line lottery systems as long or as intensely as GTech has. To the politicians making buying decisions, a proven track record is a paramount consideration. Politicians are particularly sensitive to lotteries—if something screws up, a political leader may well pay the price. On-line networks differ from other gambling systems because they involve wiring an entire political jurisdiction, says analyst Edward McSweeney III of Ladenburg Thalmann & Co. On the other hand, he says, computer and telecommunications companies now entering the field, such as Control Data, General Instrument, and BCE, may have proven records in transaction processing, but they do not have the overseas on-line lottery contacts or know the ideosyncracies of the business.

The question of ongoing support may be another factor. Because it sells only lottery systems, GTech is the least likely of all the major contenders to back out of the business.

That doesn't mean GTech is taking success for granted. The company continues to hone its technology. Like any good gambler, it understands that there's no such thing as a sure bet. ■

Editorial assistant Kenan Woods contributed to this article.



DAVID HERBICK

On Technology's Mitch Kapor

ON SOFTWARE STARTUPS

FOR MITCH KAPOR, starting personal-computer software companies is becoming a lifelong pursuit. In 1981, he parlayed his concept for spreadsheet software into Lotus Development Corp. As president and later chairman, he led Lotus to more than $200 million in sales in just three years, establishing its 1-2-3 program as the spreadsheet standard. Looking for new technological challenges, Kapor resigned from Lotus in 1986. Late last year he started On Technology, over which he presides as chairman.

On Technology is developing programs for the new Operating System/2 (OS/2)—a powerful control system for the new generation of IBM and compatible personal computers. Unlike Lotus, which makes software for computer users themselves, On Technology will sell software that programmers can use to produce better programs.

That makes On Technology both a new venture and a new direction for the 37-year-old startup veteran. To get his views on the most promising directions in software, assistant managing editor Jeffrey Zygmont visited Kapor at On Technology's offices in Cambridge, Mass.

Mitchell Kapor

Born: Nov. 1, 1950
Founded Lotus: 1981
Founded On Technology: November 1987
Responsibilities: Overall strategic planning; software development
Seed money provided: $1 million

■ *HT Business: Is it harder for a new company to get into personal-computer software today than in 1981?*

KAPOR: No, I don't think it's harder to get into. I can't tell because I'm not just starting out now; I've lost my innocence. But I think there are still frontier areas and big for-

SETH RESNICK/PICTURE GROUP

tunes to be made and big companies to be built. Most of the new companies will fail, just as they always have. But there's still very rapid change in the underlying technology, creating opportunities to marry technology to people's needs.

■ *HT Business: What does personal-computer software need today?*

KAPOR: At the most general level, software doesn't do enough, and what it does do is too difficult to use. In other words, there are islands of success in a sea of frustration. There's no software yet for people who work with ideas and items of information, the way there are spreadsheets for people who work with numbers. Everybody I know gets frustrated with his PC at one time or another. Some people are more embarrassed to admit it than others, but at least twice a week I want to throw the whole machine through the window. That's a sure sign that we haven't reached a fine level of sophistication in software. I don't think that fact is taken into account by most people in the industry.

For the last two or three years one of the principal bottlenecks has been the absence of an operating system for the dominant personal-computer architecture, the IBM PC and compatibles capable of addressing more than 640K memory.

■ *HT Business: Is OS/2 filling that gap?*

KAPOR: Until Presentation Manager [OS/2's graphic commands that will work the same way for all programs] ships, there's still a barrier to good software. OS/2 without Presentation Manager is just another character-based interface.

I think the Macintosh is one of the stellar examples of success in the whole personal-computer arena. Its graphical user interface is genuinely easier to learn and easier to use, without sacrificing power and capability.

■ *HT Business: Is that why your new company is developing software for the Macintosh first, before OS/2?*

KAPOR: Well, Macintosh is here now, and we like it better. It's cleaner. This is obviously not a final opinion, but I think Presentation Manager is more compromised by the political process of hammering it out between Microsoft and IBM, and by the fact that it's going to coexist in a world that still has a lot of character-based applications. So we really won't be seeing it produce a primary mental change in the way people approach computers. It may do things the Macintosh doesn't, but emotionally I think the Macintosh wins hands down.

■ *HT Business: Do you expect OS/2 to replace MS-DOS?*

KAPOR: Not completely. I don't think that DOS will go away the way CPM [another operating system] virtually went away. There are too many people using DOS software and too many machines that can't run OS/2. Their owners won't want to upgrade hardware. In terms of momentum, in terms of new products, I think that development of new DOS products will come to a crashing halt over the next 12 months.

■ *HT Business: What are other problems with today's software products?*

KAPOR: Broadly speaking, you can separate what goes on in a computer into two pieces: things having to do with the display—what you're interacting with on the screen—and things having to do with the data, how it's organized and structured inside the computer. The big progress has been in the first area, in dealing with users. I'm sure there will be much more evolution, but right now the display is way ahead of data manipulation.

For instance, it's not at all uncommon to spend 15 minutes trying to find a document, by opening all the documents in a directory. There are much better ways to organize information that let people use methods that are much more compatible with the way they think. In some sense, you want to address the content of documents. Everything should work that way, not just word processing.

Another need is software designed to support the activities of work groups. Such software doesn't really exist today, although there's a lot of interest in it. Take word processing. It's very common for organizations to have a document that is collectively authored, like a report or a business plan. These documents go through stages. Somebody writes something, people make comments on it, the comments are incorporated into it. Word processors don't assist you in that today. People would like to be able to do their commenting and revisions on line, and have the program automatically accumulate the collective comments so rewriters can pick and choose among them and send messages back to the reviewers. To facilitate that type of application, you need some higher-level, more structured way of organizing all the items of information that comprise the document.

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"Development of new DOS products will come to a crashing halt over the next 12 months."

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The issue also comes up when you talk about data services—say, the Dow Jones. Such services are a really good idea; lots of people are interested in them, but they are intolerably difficult to use. I'd like to have some way of saying what I was interested in by company, by subject matter, by when an event happened, and then have the service simply propose a list of relevant stories collected from everywhere in the database. What I'd really like to do is tell an on-line computer service the sort of information that I'm interested in and leave a standing order to have the information delivered. You can't do that with today's services, but it's conceivable that you could do it with new software, new kinds of information systems.

■ *HT Business: How is your new company, On Technology, addressing these problems?*

KAPOR: I've been trying to sketch out the case that, regardless of whether you're talking about personal, group, or public information systems, there are some common ways of

structuring data, ways of allowing people to specify what they want. You want to let people do programming without learning how to program. On Technology is trying to build a single set of building blocks, a solid platform that other software companies can use to create and deliver these kinds of information systems.

Compare this to the start of the automobile industry. We're going to start by building an automobile engine. As we build the engine, we'll also sort out whether we're going to make trucks or cars or motorcycles, or to what extent we will sell other people our engines.

■ *HT Business: Are you taking this approach because you believe that, for the next generation of software, you have to start at a lower, building-block level?*

KAPOR: I don't think you have to. I think it's perfectly possible to build some applications one at a time that will deliver a certain level of benefit. I think that the benefits of the building-block approach are similar to the benefits of the Macintosh: You do it once and do it right and convince other people to use it and everybody wins, because you get much more synergy between the different applications and services created from the building blocks. Different programs work with each other, even though the creators of the individual products didn't cooperate with each other.

■ *HT Business: It sounds as if you're trying to benefit the entire computer industry, not just your new company.*

KAPOR: I'm interested in playing in an arena where it's possible to have a broad impact on computing and society. I would be happy if something I did helped in the broader sense. When personal computers first came out, I got excited about them at a very visceral level, a level deeper than commercial motives. I'm still excited, and I'm still finding ways to express and channel that excitement into useful products. The second time you go out on a mountain-climbing expedition you try to go very well prepared, and you go after a very tall mountain.

■ *HT Business: Such talk of a broader vision and new frontiers reminds me of the change-the-world rhetoric that was rampant in the early days of personal computing.*

KAPOR: It is a very broad vision, but that doesn't logically imply that computers are going to save or change the world. In fact, I'm opposed to the messianic view of personal computers as the salvation of mankind. That's pretty silly. On the other hand, I think that they can and will make a difference, the way other major technologies have—the printing press, radio, telephone. I think that PCs are already in that league. So the issue is, are we just going to let things happen, or are we going to try to do what we can to steer their usage into more productive, more interesting, more valuable channels?

■ *HT Business: In other words, you think computers can do more for us and you want to discover a way to encourage that?*

KAPOR: Exactly. A particularly fertile area is the interaction of computer technologies with communications technologies. I think On Technology is going to wind up focusing on this sort of interaction.

If you look at Dow Jones and Compuserve and MCI Mail and all these bulletin boards, it's as if PCs had never happened. At heart, these services all assume that what's at the other end of the line is a teletype-like terminal. PCs have contributed to this, as terminal-emulation programs have gotten fancier and fancier. They have capture buffers, off-line editing, automatic logging, learning sequences, and the usual stepladders to the moon. Do you know that analogy? It says that if you want to get to the moon you climb on top of your house and put up a ladder, and you figure if you keep adding ladders you'll get there. It just doesn't work.

■ *HT Business: If you were starting out in your garage without a name in the industry, without private capital, would you be taking the same product approach that you are now?*

KAPOR: I couldn't—I couldn't take so long to develop it or be this ambitious. I'd shift the enterprise to fit the circumstances. That's always the same; if the circumstances are different, then the enterprise should be different. I have a standard set of advice for people who are starting out: Get a lot of experience, get immersed in the particular culture of whatever it is that you're doing, get to know a lot of people, find out what makes a thing tick, try to get involved in somebody else's startup for a while and make mistakes on their money. See how it's done.

■ *HT Business: Is an entrepreneur a different type of person than a corporate executive, or can one person be both?*

KAPOR: Running a big business is very different; you have to worry about the business. If you're starting something new, you have to worry about the thing you're making. In a big business, you wind up having to deal with Wall Street and next quarters and market share and a national sales force. You're not concentrating on creating a whole new information industry.

■ *HT Business: So you think it's rare to find both an entrepreneur and a corporate executive in the same person?*

KAPOR: Yes. Rare, but not unprecedented.

■ *HT Business: Does that mean you will never stay long with an established business?*

KAPOR: I don't know. I was with Lotus for about five years. But that's going from zero revenue to about $250 million—that's like a lifetime. If you count that as experience instead of years, it's about 20 years' worth.

The challenge for me is to do something where I won't feel that I have to leave if it's successful—to still find it motivating and exciting. There are different kinds of businesses. Some are more technology oriented, where it's more important to be a technology leader because that's where the leverage is. These tend to be systems-software businesses; Microsoft is an example. In other businesses, you have to be more customer oriented; Lotus is that kind of business. One of the reasons I'm doing something that is more systems-software oriented is because that has far-reaching implications for the company. It will create a different kind of atmosphere, a different set of values, a different sense of community, a different corporate culture. Of course, the challenge is to make it a successful business; you can't have a little retirement home for programmers, which I wouldn't want anyway. That's where the entrepreneurialism comes in.

I think there's a wide variation of interesting and innovative things that you can do. I'm just trying to find something that is more suitable for a longer period of time. We'll see. ■

LEADING 100

COMPANY (SYMBOL/EXCHANGE)	RANK THIS MONTH/ LAST MONTH	PRICE INCREASE LAST MONTH (%)	CLOSING PRICE ($)	EARNINGS PER SHARE LAST QUARTER ($)	EARNINGS PER SHARE CHANGE FROM 1 YEAR AGO	LATEST DIVIDEND ($)	P/E RATIO	DEBT/ EQUITY RATIO	LATEST 12 MONTHS' REVENUE (IN MILLIONS)
AEROSPACE									
Sierracin (SER/AMEX)	1/9	33.2	7.50	.16	300.0	—	15.6	.38	72.8
Grumman (GQ/NYSE)	2/25	23.4	23.75	–1.23	–100.0	1.00	NE	.88	3,325.1
Matec (MXC/AMEX)	3/15	15.4	5.63	.04	–69.2	—	62.5	.22	20.7
Ronson (RONC/NASDAQ)	4/1	13.8	3.63	.09	NE	—	20.1	2.84	31.0
Kaman (KAMNA/NASDAQ)	5/3	10.9	17.75	.36	20.0	.40	13.0	.55	707.5
Fairchild Ind. (FEN/NYSE)	6/10	9.3	10.25	–.18	NE	.20	NE	2.39	453.8
Watkins Jhnsn. (WJ/NYSE)	7/13	9.2	28.38	.58	41.5	.40	13.3	.26	264.3
OEA (OEA/AMEX)	8/30	8.0	21.88	.36	.0	—	13.6	.00	42.2
Rockwell (ROK/NYSE)	9/20	5.3	19.88	.71	39.2	.72	8.0	.23	11,936.4
Sequa (SQAA/NYSE)	10/12	5.2	65.75	1.46	55.3	.60	3.2	.43	976.5
CHEMICALS									
Spec. Comp. (SPCM/NASOAQ)	1/81	40.0	5.25	.13	160.0	—	17.5	.65	9.3
Hyponex (HYPX/NASOAQ)	2/75	30.1	8.13	–2.18	NE	—	NE	.88	124.6
Huntingtan (HRCLY/NASOAQ)	3/7	21.7	24.50	.51	155.0	—	18.3	.14	71.7
Hawkins Chem. (HWKN/NASOAQ)	4/13	21.4	8.00	.13	62.5	.12	16.3	.01	33.3
Borden Chem. (BCP/NYSE)	5/61	17.6	15.88	NA	NA	—	NA	NA	NA
Norsk Hydro. (NHY/NYSE)	6/41	16.0	31.75	–.15	–100.0	—	NE	5.05	7,367.2
Stepan (SCL/AMEX)	7/72	15.8	47.75	.96	71.4	.92	13.0	.63	288.9
Diam. Cryst. (OSLT/NASOAQ)	8/64	15.5	33.50	.08	–68.0	.80	44.7	.01	132.5
Essex Chem. (ESX/NYSE)	9/73	15.5	19.50	–2.57	–100.0	.52	NE	.62	208.8
Kinork (KIN/AMEX)	10/82	14.1	3.00	–1.37	NE	—	NE	.78	28.4
COMMUNICATIONS									
ACC (ACCC/NASDAQ)	1/4	92.0	3.13	.24	1100.0	—	28.4	.53	34.1
Artel (AXXXX/NASDAQ)	2/50	28.6	2.25	–.10	NE	—	NE	.00	5.1
ADC Tel. (ADCT/NASDAQ)	3/22	18.7	22.25	.34	78.9	—	16.7	.04	177.7
Ericsson (ERICF/NASOAQ)	4/43	17.8	40.63	–.33	–100.0	—	22.3	.38	4,721.2
Millicom (MILL/NASOAQ)	5/41	16.3	14.25	.34	–86.2	—	5.4	.00	45.7
Cell. Comm. (COMM/NASOAQ)	6/17	15.9	25.50	–.42	NE	—	NE	2.64	34.7
ALC Comm. (ALCC/NASOAQ)	7/8	15.2	2.88	–.20	NE	—	NE	2.39	394.6
Adv. Tel. (ATEL/NASOAQ)	8/14	13.6	18.75	.30	30.4	—	15.8	.26	87.5
Intl. Mob. Mach. (IMMC/NASDAQ)	9/58	12.9	9.88	–.53	NE	—	NE	.01	2.4
Centel (CNT/NYSE)	10/15	12.1	48.50	1.16	1060.0	1.72	13.5	.86	1,475.8
COMPUTERS									
Endotronics (ENDOQ/NASOAQ)	1/191	89.3	1.06	–.06	NE	—	NE	.00	3.5
Masstor Sys. (MSCO/NASOAQ)	2/117	61.3	3.13	.00	–100.0	—	NE	.16	38.5
Fronklin Cptr. (FOOS/NASOAQ)	3/188	51.5	18.75	.29	NE	—	49.3	.47	39.5
Verdix (VROX/OTC)	4/185	42.0	1.25	–.02	NC	—	NE	.14	5.6
Tigera Grp. (TYGR/NASOAQ)	5/173	41.3	1.06	–.24	–100.0	—	NE	.01	.4
Norsk Data (NORKB/NASOAQ)	6/103	41.2	12.00	.00	–100.0	.35	NA	.86	394.1
Par. Tech. (PTC/NYSE)	7/170	39.1	8.00	–.23	–100.0	—	NE	.00	57.3
Comp. Microfilm (COMI/NASOAQ)	8/43	38.7	5.38	.09	50.0	—	15.8	.60	11.8
Scan–Tron (SCNN/NASDAQ)	9/70	36.2	16.00	.18	50.0	—	17.6	.49	30.4
Fingermatrix (FINX/NASDAQ)	10/7	34.7	3.88	–.12	NE	—	NE	.00	.2
DRUG MANUFACTURERS									
Biomerica (BMRA/NASOAQ)	1/88	70.4	1.38	–.22	NE	—	NE	.00	1.8
A L Labs (BMO/AMEX)	2/24	35.0	13.50	.22	120.0	.12	18.5	.33	156.7
Lifecore Bio. (LCBM/NASDAQ)	3/58	34.4	4.88	.00	NE	—	NE	.07	3.2
Hycor Biamed. (HYBD/OTC)	4/4	22.5	1.69	.02	100.0	—	28.1	.08	7.0
Barr Labs (BRL/AMEX)	5/48	17.2	8.50	.09	–57.1	—	19.8	.26	58.0
Cooper Devel. (BUGS/NASOAQ)	6/83	15.2	13.25	–.47	–100.0	—	NE	.02	.7
Scherer RP (SCHC/NASOAQ)	7/31	14.5	17.75	.28	40.0	.36	17.9	.40	270.6
Nature's Sunsh. (AMTC/NASOAQ)	8/41	13.9	11.25	.25	127.3	—	12.4	.02	38.2
Summa Med. (SUMA/NASOAQ)	9/19	13.0	1.56	.38	NE	—	NE	.72	9.3
Smith Labs (SMLB/NASOAQ)	10/73	12.6	1.97	.01	NC	—	NE	.11	10.1

The HIGH TECHNOLOGY BUSINESS Leading 100 lists the 10 companies in each of 10 industries that had the highest stock gain over the previous month (figures as of 4/7/88).

NA Not available NE Negative earnings NC Not calculable NM No meaningful figure

COMPANY (SYMBOL/EXCHANGE)	RANK THIS MONTH/ LAST MONTH	PRICE INCREASE LAST MONTH (%)	CLOSING PRICE ($)	EARNINGS PER SHARE LAST QUARTER ($)	EARNINGS PER SHARE CHANGE FROM 1 YEAR AGO	LATEST DIVIDEND ($)	P/E RATIO	DEBT/ EQUITY RATIO	LATEST 12 MONTHS' REVENUE (IN MILLIONS)
ELECTRONICS									
Cetec (CEC/AMEX)	1/181	112.1	10.88	.03	50.0	.20	32.0	.19	33.8
Dyansen (DYAN/NASDAQ)	2/187	61.3	2.63	.05	66.7	—	10.9	.35	25.9
VMX (VMXI/NASDAQ)	3/241	40.8	3.00	–.27	NE	—	NE	.00	29.3
Seeq Tech. (SEEQ/NASDAQ)	4/26	40.3	8.25	.15	NE	—	11.6	.21	50.9
Elec. Missiles (ECIN/NASDAQ)	5/146	39.5	1.13	–.06	NE	—	NE	2.29	4.2
Astro Med. (ALOT/NASDAQ)	6/235	38.9	12.50	.21	110.0	—	18.9	.28	16.3
Adv. Circuits (ADVC/NASDAQ)	7/180	37.7	4.13	.06	500.0	—	NM	.58	77.5
Armatron Intl. (ART/AMEX)	8/74	35.2	2.88	–.15	NE	—	NE	.26	21.3
Kevlin Micro. (KVLM/NASDAQ)	9/191	35.2	2.88	.05	NC	—	NE	.00	7.3
Cinn. Micro. (CNMW/NASDAQ)	10/246	34.4	4.88	.17	466.7	—	7.2	.00	80.9
HEALTH									
Intl. Clin. Lab (ICLB/NASDAQ)	1/3	58.4	36.63	.12	33.3	—	47.6	.77	228.8
Intermedics (ITM/NYSE)	2/25	55.9	27.88	.40	135.3	.03	19.2	.10	202.2
Oomon (DMN/NYSE)	3/42	52.5	26.88	.14	NE	.20	67.2	.33	185.8
Exovir (XOVR/NASDAQ)	4/74	39.1	8.00	–.15	NE	—	NE	.00	.1
Survivol Tech. (SURV/NASDAQ)	5/100	38.3	6.75	–.16	NE	—	7.3	.70	32.8
Spectron (SPTR/NASDAQ)	6/82	38.2	1.81	.44	NE	—	NE	.16	3.3
Hemotec (HEMO/NASOAQ)	7/48	37.5	2.75	–.37	–100.0	—	NE	.35	4.6
Kirschner Med. (KMDC/NASDAQ)	8/49	33.9	18.75	.15	1400.0	—	30.7	.20	17.1
Sci–Med Life (SMLS/NASDAQ)	9/5	33.3	18.00	–.11	–100.0	—	NM	.00	13.6
Abiomed (ABD/AMEX)	10/98	28.3	10.75	.00	NC	—	NE	.00	4.5
METALS FABRICATION									
Edgecomb (EDGC/NASDAQ)	1/35	29.6	4.38	.00	NE	—	54.7	18.54	555.5
Vorlen (VRLN/NASDAQ)	2/37	22.6	19.00	.14	NE	.60	12.4	.81	169.9
Columbio Gen. (CLGN/OTC)	3/33	22.2	5.50	.15	–44.4	—	2.9	.42	54 1
Cml. Metals (CMC/NYSE)	4/9	20.2	26.75	.81	252.2	.44	13.4	.23	994.1
Fansteel (FNL/NYSE)	5/27	16.3	12.50	–.11	NE	.60	NE	.48	176.3
Material Sci. (MSC/AMEX)	6/13	15.4	17.75	.20	–50.0	—	20.2	.74	147.1
Trinity Ind. (TRN/NYSE)	7/14	15.0	33.50	.26	271.4	.50	79.8	1.28	583.8
Struthers Wells (SUW/AMEX)	8/16	13.0	1.13	–.01	NE	—	NM	.28	17.3
Steel Tech. (STTX/NASDAQ)	9/40	12.4	15.00	.17	41.7	.02	20.3	.44	89.2
Pitt Des Moines (PDM/AMEX)	10/38	12.2	20.75	1.27	–17.0	—	NE	.32	276.3
SCIENTIFIC AND ELECTRONIC INSTRUMENTS									
Isomet (IDMT/OTC)	1/76	40.0	5.25	.35	NE	—	13.8	.07	8.6
Bear Auto Svc. (BEAR/NASOAQ)	2/60	30.1	7.00	–.15	–100.0	—	NE	.63	90.6
Ariz. Inst. (AZIC/NASDAQ)	3/87	29.5	3.56	.05	–50.0	—	15.5	.20	8.9
Laser Photo (LAZR/OTC)	4/95	28.4	1.13	–.02	NE	—	NE	1.45	4.6
Chronar (CRNR/NASDAQ)	5/63	27.2	7.63	–.03	NE	—	NE	.22	17.0
Tenney Eng. (TNY/AMEX)	6/80	25.3	1.88	.02	.0	—	NE	.44	18.9
Isco (ISKO/NASDAQ)	7/27	22.6	16.25	.27	125.0	.20	17.7	.00	27.8
Nicolet Inst. (NIC/NYSE)	8/28	20.9	13.00	–.86	–100.0	—	NE	.05	135.2
Electro. Sensors (ELSE/NASOAQ)	9/89	20.0	4.50	.08	–27.3	.10	9.8	.00	4.3
Oaniel Ind. (OAN/NYSE)	10/36	17.9	9.88	–.07	NE	.18	NE	.13	137.2
SOFTWARE AND OATA PROCESSING									
Network (NTWD/OTC)	1/116	126.0	1.13	–.10	NE	—	NE	.00	.2
Automated Sys. (ASII/NASOAQ)	2/145	60.0	4.00	–.13	–100.0	—	NE	.08	11.2
Algorex (ALGO/NASDAQ)	3/139	54.3	2.13	–.09	NE	—	NE	1.40	6.4
Worlco Oata (WDSI/NASDAQ)	4/121	42.0	1.25	–.06	–100.0	—	NE	.60	11.4
Citzns. Fncl. (CTZN/NASDAQ)	5/53	30.0	6.50	.16	.0	.08	9.6	.00	11.3
Infodata Sys. (INFD/NASOAQ)	6/137	29.3	3.88	.07	600.0	—	12.5	.05	11.5
Aero Svc. (AERO/NASDAQ)	7/126	29.1	2.75	–.28	–100.0	—	NE	1.87	66.6
Telos (TLOS/NASDAQ)	8/131	28.2	12.50	.27	50.0	—	12.4	.00	93.9
Cycore Sys. (CYS/NYSE)	9/104	23.7	9.75	.02	–84.6	—	22.7	.15	67.1
Computroc (LLB/AMEX)	10/3	23.1	4.00	–.17	–100.0	.07	NE	.11	7.7

SOURCE: MEDIA GENERAL FINANCIAL SERVICES

GET THE EDGE

In case you missed any of these stories when they appeared in HIGH TECHNOLOGY BUSINESS, here is a selected listing from the past year. Check the stories you want and fill in the form. Include $5 for each story to cover photo-copying, postage, and handling.

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SUPERCONDUCTIVITY

The Cambridge Report on SUPERCONDUCTIVITY

Top Three Compounds Get Attention

The periodic table of chemical elements is rapidly becoming a festive superconducting smorgasbord. Those who know their way around the table are having a feast.

Those scientists and journalists who were beginning to bemoan a "slowing down" in superconducting research and development are now hard-pressed to keep up with the rapid-fire announcements of new materials.

Scientists are now working with three proven superconducting compounds: the original yttrium-barium-copper compound, the bismuth-based compound, and a thallium-based compound—the latter two discovered just this year. Moreover, a fourth compound based on indium is getting attention in some labs.

Scientists who have analyzed the rare-earth/copper-oxide compounds have found atomic structures based on copper-oxide planes that seem to characterize all the validated oxide superconductors. The researchers are now substituting various elements to replace the expensive rare earths or poisonous thallium.

Here is a rundown on the latest materials getting attention as superconductors:

1. The bismuth-based compound. This mixture of bismuth, copper, strontium, and calcium was discovered nearly simultaneously in Japan and the U.S. Initial reports claimed Tc (the superconductivity temperature) at 114° Kelvin, up to 120° Kelvin—a clear improvement over the 1-2-3 compounds in which the best Tc was 90° Kelvin.

Researchers have since discovered that the bismuth compounds start to become superconducting at 120° Kelvin, but reach actual zero resistance at between 90° Kelvin and 100° Kelvin. They have discovered both advantages and disadvantages compared with the 1-2-3 compound.

On the plus side, researchers at both AT&T's Bell Labs and Superconductor Technologies Inc. of Goleta, Calif., say that critical current capacity of the bismuth-based material appears to be higher than the yttrium-based compound. Both organizations decline to provide figures, saying that their results are thus far inconsistent.

Says an AT&T researcher: "Here's reason for optimism that there may be ways to deal with [the bismuth material] and get high critical current wires."

Much uncertainty still exists about current-carrying capacity. Some initial work showed it to be only 250 Angstroms per square centimeter in bulk samples, which is lower than the capacity achieved in the 1-2-3 compound.

On the down side, the material is inconsistent from batch to batch, though Superconductive Components Inc. of Columbus, Ohio, has improved reproducibility by adding 6 percent lead to the bismuth compound. The AT&T researcher says that superconducting sometimes occurs at 80° Kelvin and sometimes up to 120° Kelvin, apparently because of very subtle differences in composition.

2. The thallium-based compound. Allen M. Hermann and Z.Z. Sheng of the University of Arkansas in Fayetteville substituted thallium for bismuth and achieved true Tc at 106° Kelvin in late January. In ear-

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ly March, IBM researchers achieved true Tc at 125° Kelvin by using optimum proportions of thallium, calcium, barium, copper, and oxygen.

On the plus side, the thallium compound is very easy to reproduce and fabricate. On the other hand, the thallium compound is a deadly poison and researchers in a number of labs have already said they won't allow it in the door.

3. The indium-based compound. Rumors that Alex Muller of IBM was preparing to present a paper on a superconductor substituting nontoxic indium for thallium had several labs and companies preparing samples. In its unfilled outer ring of electrons, indium is identical to thallium. Consequently, indium may offer the superconducting performance of thallium without the danger.

ENERGY

Coal & Synfuels Technology

Test Bodes Well for Gasification

A government/industry underground coal gasification (UCG) test in Wyoming is more than half finished and is beginning to provide information its developers say proves the technology has a chance for commercial success.

The Rocky Mountain I project, located on a snow- and wind-swept plain in a desolate area near Hanna, Wyo., was opened to observers early this year as the test burn neared day 70 of its planned 100-day run. Operations began November 16. In January, about 10,000 tons of coal were gasified in two different test modules to produce nearly 250,000 cubic feet of gas. The test is taking place in the Hanna 1 coal seam, which is about 30 feet thick and 350 feet deep.

The federal Energy Department and an industry consortium headed by the Gas Research Institute of Chicago are sponsoring the $13 million test.

Two UCG technologies are being tested side by side, and so far the controlled retracting injection point (CRIP) method appears to be outperforming the extended linked well (ELW) method.

The CRIP method involves placing an igniter in a burnable lining into the coal seam. The coal is ignited, and combustion is aided with the injection of oxygen and steam. Gas exits at one of two production wells. When combustion begins to dwindle, the igniter is pulled back, or retracted, and the liner housing is burned. The process is repeated in successive maneuvers until the entire seam is gasified.

The ELW method entails more conventional UCG technology whereby one vertical injection well is drilled for each burn zone.

Project managers recently began burning the third zone in the CRIP test. Three CRIP burns originally were planned, but the test was so successful that the sponsors are talking about conducting a fourth CRIP burn. Meanwhile, they have flushed the ELW burn cavity to cool it off after completing the last of two planned burns. Problems with the second well forced an early finish.

The test was expected to result in an average daily consumption of 100 tons of coal, with an average of 24 scf/ton of medium-Btu gas for each of the two technologies. Project managers said recently that the CRIP method is about 50 percent more efficient so far than the ELW method. Both are producing about the expected yield per ton, with CRIP producing far more of a better quality gas than ELW.

Among the key objectives of Rocky Mountain I are to demonstrate UCG's economics and environmental safety—two of the remaining, serious obstacles to commercial acceptance. Past tests in the U.S. have shown that the technology works, but costs were too high and, in some cases, the tests caused severe groundwater contamination.

Proponents of UCG say it costs less than surface gasification because expensive surface facilities and equipment aren't needed. The test project consists of a series of above-ground pipes, oxygen storage tanks, incinerator and flare, and several trailers and shacks to protect equipment from the harsh Wyoming winter.

The project's sponsors have said it appears pipeline-quality gas can be produced from UCG at $3 to $3.50/mmBtu. A glut of natural gas in Wyoming has kept prices around $1.70/mmBtu.

The costs are projections at this point and may change as more data comes in, the sponsors cautioned. Also, natural gas prices are negotiated, not fixed, so comparisons are rough estimates only, they said.

Officials with the Wyoming Department of

Environmental Quality said they have received at least five inquiries about the project over a period of severl weeks earlier this year. The callers, most of them state and county politicians, wanted to know more about the commercial potential of the technology, department officials said.

Whether commercial projects can be built depends in part on whether the department gives Rocky Mountain I, which has been extensively monitored, a clean bill of environmental health.

MATERIALS SCIENCE

INDUSTRIES IN TRANSITION

Drying Industry Heats Up

Various drying techniques have been around for a number of years. Freeze drying debuted during World War II when it was used to dry and preserve pharmaceuticals and blood plasma. In the 1970s, the process emerged to preserve foods, including fruits and vegetables. Now freeze drying is being more widely exploited for other applications.

Other drying techniques are also available and a new process in the U.S. is less expensive than freeze drying. This continuous low-temperature dryer is thought to have some advantages over the other techniques, which also include vacuum drying and spray drying. The newer technique has been applied to eggs, fruits, vegetables, and fish, as well as enzymes, vitamins, yeasts, and antibiotics.

The drying principal of the new technique is fairly simple. The product to be dried is applied to drying balls in the application zone of the dryer. As the drying balls and product move continuously downward at an adjustable speed through the drying zone, they pass a countercurrent stream of temperature-controlled drying air.

In the separation zone at the bottom of the dryer, the drying balls and product meet a co-current flow of air for final drying and separation of product and drying balls. The drying balls are recycled to the application zone, where the process continues.

Freeze drying involves the rapid freezing of a porous material followed by rapid dehydration by sublimation in a high vacuum. In certain applications such as biologicals, this method of dehydration has some advantages over other drying techniques in that the driving force of the dehydration is not heat but the difference between the vapor pressure of the porous material and the condenser plate.

Freeze drying is the more expensive technology. For some applications, however, the benefits are worth the expense. One such application is making a homogeneous material for ceramics, including superconductors. One of the difficulties in making sensitive ceramics, such as semiconductors, is getting a uniform composition. Freeze drying forms a homogeneous microporous ceramic structure and gas escapes in an orderly fashion, reducing the incidence of fractures. Freeze drying is also finding use in chemical processing to separate solvents and solutes. The process can also remove water from a water-based latex polymer so it can be mixed with other materials.

With four distinct techniques available for drying and many new applications being found, all drying techniques are going to find wider use. Where a number of freeze-drying companies do the drying, the new continuous drying equipment will be sold to the user. This will permit companies to choose their own solution to drying.

SEMICONDUCTORS

SEMICONDUCTOR ECONOMICS REPORT

1988 Has Become the Crossover Year for DRAM Chips

The key question for any system designer is, when will the switch to the newer DRAM design occur? Historically, a DRAM (dynamic random-access memory) product life cycle takes about three years, and the crossover to the new design typically occurs one year after the peak of the product market.

A DRAM product goes through four stages: introduction, growth, maturity, and decline. However, at any one time the industry will have two to three products in various stages. For example, one-megabyte devices are now in the growth part of the cycle, while 25-kilobyte circuits are declining. This is the year

when a switch, or crossover, will occur between the two designs.

Typically, the crossover in orders occurs when the market price of the new part declines or is expected to decline to about five times that of the existing product. This is happening with the 256-kilobyte units in the $2 to $3 range and one-megabyte units at artificially high prices of $15 to $20. Based on present costs, and without present shortages, these units could sell for $10 to $12 at fair market value.

Although the four-megabyte DRAM has been announced since early 1987 and is now in the introductory phase, the crossover to this product will not occur until late 1990. Further, considering the compressed time cycle and the loss of the cost-improvement curve on these products, the pricing will be higher, possibly in the $30 range.

Performance vs. Resolution

Why has the industry continually pushed to higher process resolution? The primary reason is cost. Several months ago, when Intel Corp. broke ground for a $95-million, 0.7-micron-wafer fabrication facility, Gordon Moore stated, "The cost-per-bit of devices produced at this new facility is estimated to be 17 times less than Intel's present 1.5-micron facility and 2,500 times less than the original Mountain View facility, which was constructed in 1979." These are typical cost improvements based on both bit-count-per-wafer and the higher yields-per-bit based on the typical yield vs. area relations.

However, there are other benefits to higher-resolution processes. The design engineer gets a higher-performance device. Additionally, the efficiency in terms of gate power-delay products is improved. The result is not only faster gates or memory cells, but also parts that will run cooler and be more reliable.

In theory, the gate delay time will be reduced by the square of the design resolution. So, in theory, a one-micron part will switch four times faster than a two-micron part. Assuming a fixed supply voltage, the power per gate will increase, but the power-delay product—the key parameter—will still decrease by a factor of two.

The Very High Speed Integrated Circuits (VHSIC) program is an example where performance goals were obtained by higher resolution. The present 1.25-micron process and the projected 0.5-micron process provided both the speed and the on-chip density to obtain system speeds for real-time computing capabilities.

AEROSPACE

Space Business News

Ge Picks Titan as Rocket of Choice

General Electric's recent deal with Martin Marietta to launch 15 company-built satellites on commercial Titan rockets doesn't contractually commit GE to buy anything, according to a company source. But it does establish Titan as GE's rocket of choice, and will result in substantial business for Martin over the next several years.

This deal marks the first time a satellite manufacturer has agreed to purchase launches for more than a small, set number of satellites. The agreement could smooth out operating details between the two companies and prove an effective marketing tool for GE, which has bid to build several satellites that could fly on commercial Titans.

While the specific details of the agreement have not been disclosed, it does provide GE with "assured launch and reflight features as well as certain manifesting priorities and operational advantages," according to a statement by the companies. A Martin official said that, to derive certain price benefits, GE must buy the 15 rides within the agreed-upon time frame.

But GE maintains it still intends to be responsive to its customers' lift choices. Charles Schmidt, vice president and general manager of GE's Astro Space Division, said, "While the Titan will be the preferred launcher for GE launches, GE will continue to be totally responsive to customers' wishes or program requirements for alternative launch-vehicle selections."

Exercise of all the launch options would bring to 19 the total number of satellites booked to launch on commercial Titan rockets, beginning in 1989. A Titan marketer said that the practice of lining up a launcher of choice may eliminate the practice of putting up cash to reserve a particular launch and

help standardize launch prices.

Even with the GE commitment, there's plenty of room for other commercial customers. Martin can launch five commercial Titans yearly or 10 in a dual mode. Intelsat VIs, two of which are hooked on commercial Titans, must fly singly. Even then, assuming GE's launches are on a fast track, it can market at least six full rockets through 1991.

GE has several satellites built or nearing completion, but some are hooked on Ariane: SES's Astra, PanAmSat, Spacenet 3R, two GStars, Anik E-1 and 2. GE is talking to Ariane about launching GE Americom's K4, but K3 was a shuttle candidate and may shift to Titan. NASA's advanced communications satellite (ACTS) is also scheduled on the shuttle.

COMPUTERS

ANDREW SEYBOLD'S OUTLOOK ON PROFESSIONAL COMPUTING

Macintosh Communications Gets a Helping Hand From a Number of Independent Companies

First came the AppleTalk personal network. It was great for connecting small workgroups. Since the isolated workgroups of about two years ago usually consisted of only three to eight Macintoshes and a shared printer, everything could be easily hooked together with the same shielded twisted-pair wires.

At this stage, everything worked fine, even if the network was a little slow at times. But the AppleTalk configuration was not very "corporate." Indeed, most corporations had something else in mind: larger, more integrated (read controlled) workgroups, with all desktop machines wired to mainframes.

So what happened? A slew of third-party vendors did their entrepreneurial thing and supplied the needed connectivity. Now there's a whole spectrum of communications options designed to meet a broad range of corporate requirements—everything from various media for workgroup local-area networks (LANs) to gateways and modems for all kinds of wide-area network (WAN) configurations.

One such product is Fallon's PhoneNET LAN, which operates on standard twisted-pair telephone wiring and uses ordinary telephone connectors and accessories. Apple Computer uses it throughout its facilities in Cupertino, Calif. PhoneNET can operate over the already-installed but unused wire pairs in the wire bundles of the existing phone system. The phones and PhoneNET aren't connected; it's just that PhoneNET uses these existing phone wires which, surprisingly, are common in most companies. Alternatively, dedicated telephone wires can be strung and used.

Individual Macs, meanwhile, can be tied directly into an Ethernet backbone. Depending on the model, Macs can be connected to the backbone by various kinds of Ethernet "glue" from Kinetics: FastPath, Ether SC, and EtherPort. Kinetics' FastPath can also connect entire AppleTalk LANs to the backbone system.

Thanks to the work of third-party vendors, the AppleTalk personal network can also reach out through Abaton Technology's MultiTalk link and a modem to a remote Northern Telecom PBX, and from there to other desktop systems and to an IBM 370-architecture mainframe. In addition, the MultiTalk link can lead directly to a local mainframe and a workgroup printer.

All in all, the options are numerous and powerful, and more options are in the works. Adding to the excitement are Apple's newest offerings: MacAPPC, MacWorkStation, and that knockout product, AppleTalk for VMS. All three of these products are software options that enhance existing multivendor hardware, transforming networks and computers into single communicating entities.

IBM Forms Desktop Strategy

SAA at the desktops is, of course, best known as OS/2, the software environment IBM is counting on to win back the desktops.

OS/2 Extended Edition, or any other future edition, is not envisioned as a mere operating system like PC-DOS, or even the Macintosh OS or Unix. Rather, it's to be a whole new environment—a workgroup environment complete with all the good things that implies:

- A single, graphical user interface for all workers (with variations as needed). IBM calls this the Presentation Manager.
- The network supporting the interface will be seen

as a single resource no matter how extensive. IBM calls this the Communications Manager.

- LU 6.2 (peer-to-peer) and 3270 (master-slave) sessions interlaced. In time, peer-to-peer operations are expected to dominate. IBM calls this "responsible evolution."
- A relational database at the heart of the workgroup system, powerful workstations on individual desktops, and everything linked with a LAN. IBM calls the key parts PS/2, Micro Channel, SQL, DB2, and Token Ring.
- Multivendor products, all conforming to a distinct IBM vision of the world. IBM favors the corporate view, with tight control at the top, and gives its vision the name NetView.
- A rich set of tools, utilities, and communication services, the best of which will be supplied by third-party vendors. IBM calls its desktop partners MAPs (Marketing Assistance Program members).

Like the original IBM PC, the SAA desktop environment will likely take five years to get established. And, also like the PC, it will need the efforts of many, many players. Along the way, and especially at the desktops, SAA clones with specific dialects will almost certainly appear to expand and extend IBM's product into numerous business niches. In the end, IBM will lose control of OS/2 the same way it did the original PC.

The moral: The desktops are too robust a market to be contained by only one company. Microsoft, Ashton-Tate, Sybase, Lotus, Gupta Technologies, Sun Microsystems, Relational Technology, Touch Communications, Network Innovations, and Oracle are only a few of the vendors waiting to pounce on anything that looks like a useful connectivity standard for workgroups.

Off by itself, with DEC as a buddy, is Apple Computer, with HyperCard and all kinds of Macintosh machines, all supported by AppleShare and AppleTalk. Then there's the growing Unix gang, soon to be equipped with the new and powerful Unix V4.

The confusion at the desktops over the next several years will, at times, seem hopeless. But in the long run, the excitement will be to the customer's advantage. The fallout will be the establishment of workgroups and the steady emergence of desktop knowledge tools. The ultimate result will be an economy well prepared to compete internationally in the 21st century.

TELECOMMUNICATIONS

ISDN

IBM Moves Into ISDN Technology

Until recently, IBM Corp.'s activity in the ISDN field was perceived to be nonexistent. Many market observers doubted that the company's position would change, at least not until this new technology became established in the telecommunications industry.

However, IBM is now working with and testing ISDN technology. Its latest involvement with ISDN is in the form of a U.S. trial which began in April with Nynex Corp. in New York.

This trial, which will involve Nynex's premises and switching systems in lower Manhattan, will test IBM's Systems Network Architecture (SNA) connections over an ISDN Basic Rate Interface (BRI). The project, which may run into the 1990s, will connect the Manhattan site to a facility in White Plains, New York, using a central office (CO) switch provided by Northern Telecom Inc. The central office switch will allow the six to eight workstations provided by IBM with BRI adapters to communicate with an IBM controller also fitted with the BRI adapter. The controller will then route the data through a Nynex-owned IBM mainframe running SNA applications.

IBM's goal, according to ISDN Systems Manager John McElroy, is to identify differences in various vendors' implementations of the CCITT's ISDN interface specifications.

According to Nynex vice president of science and technology C.S Skrzypcak, "We want to know if IBM SNA applications will perform as well over unconditioned, dial-up lines to be used in the trial as they have over dedicated transmission facilities."

At Telecom '87, IBM demonstrated that its computer communications architecture, SNA, is compatible with ISDN. The demonstration produced a successful connection of a PS/2 microcomputer to an IBM mainframe through a Siemens EWSD switch.

In Europe, IBM has been involved with ISDN for more than a year participating in ISDN trials in London with British Telecommunications PLC.

Testing of IBM's new 8750 Business Communications System will begin this year in Norway and West Germany. This new line of private branch exchanges, called the 9750 BCS in the U.S., allows users to expand from 100 lines to 20,000 lines. It is based on eight-kilohertz, eight-bit sampling required for ISDN.

The Deutsche Bundespost, the West German telecommunications agency, will cooperate with IBM to test the 8750 Business Communications System for 2B+D primary rate access. The trial with the Norwegian Postal Telephone and Telegraph will test the 23B+D primary rate access.

One of the first moves made by IBM to become involved with the ISDN market was to execute a resale agreement with Network Equipment Technologies (NET) for NET's T1 network manager. In a team effort with United Telecommunications Inc., IBM will provide the database system for a Signaling System 7 intelligent network to be deployed this year.

Among a number of study agreements, IBM has also joined with the Swedish telecommunications equipment maker L.M. Ericsson Telephone Co. to further study intelligent networks. Another agreement, with Siemens AG, a major West German electronics products manufacturer, will examine how IBM might create new telecommunications services with Siemens. A third study will be conducted with Bell Atlantic International to assess the market demand outside the U.S. for a series of intelligent network applications which are based on an architecture developed for use in the U.S. by Bell Communications Research Inc.

Fiber Data Interface a Key LAN Standard

The Fiber Distributed Data Interface (FDDI) will be the most significant standard for second-generation local-area networks (LANs) through the 1990s.

FDDI will provide from 10 to 100 times greater throughput than current LANs, plus wide area coverage, high reliability and fault tolerance. Most importantly, FDDI will be the definitive solution to the LAN incompatibility and inter-operability problems associated with Ethernet, token-ring, the Manufacturing Automation protocol, proprietary networks, and custom user solutions.

Finally, FDDI is the only active standard that will keep pace with the performance demands of next-generation workstations and high-powered minis.

A proposed American National Standards Institute (ANSI) standard, FDDI will support 500 stations up to two kilometers apart, with a total expanse of 100 kilometers. A single station can support either a host computer or a subnetwork of hundreds of users.

The first FDDI version to reach the market will support packet-switching networks that provide high-performance data interconnection among computers.

The more advanced FDDI-II adds circuit switching that will enable voice, video, and sensor readouts to be integrated digitally on the same network with the computer data. It will support both the North American and European T-carrier telephone hierarchy. Thus, FDDI-II creates an all-digital broadband network with no need for a head end, and with none of the problems associated with RF carrier technology.

The key to FDDI is fiber optics. Only fiber optics allows the specified speed and distance without numerous amplifiers. Since fiber-optic communication is best suited for point-to-point transmission, FDDI is configured in a ring with active nodes. At each node, the optical signal is converted to an electrical signal, amplified, copied if necessary, and converted back to light to send to the next station.

Inherent in all ring topologies is a single point of failure, either at an active node or a cable break. To overcome node failure, FDDI provides for an optional optical bypass switch at each node. If a node fails, it is bypassed optically, removing it from the network. Up to three sequential nodes can be bypassed, and the network will still have enough optical power for normal operation.

In normal operation, both rings of a dual counter-rotating pair can be used for data traffic, raising the effective data rate to 200 megabits per second (Mbps). If one cable fails, the redundant cable will handle normal 1,000 Mbps traffic. If both cables fail, the Class A stations on either side of the failure will automatically loop the data between rings, forming the new C-shaped ring out of the operational portions of the original two rings.

First-generation LANs currently in use are incompatible, a result of the newness of the technology, a lack of previous standards, the fast growth of the LAN market, and the availability of many alternative technical solutions.

None of these problems exist with FDDI. More than 50 vendors have supported the FDDI standard's development, including Digital Equipment Corp., IBM, Unisys, AT&T, Sun Microsystems, and Apollo. The standard is mature, having been accepted by the International Standards Organization (ISO) as a working document in November 1985.

There is no competing standard. Therefore, barring any initial vendor implementation problems, all FDDI products will be interoperable. As first-generation LANs are phased out over the next decade, incompatibility problems will be eliminated.

The availability of affordable FDDI products depends on very large scale integration (VLSI) chips being developed at companies such as Advanced Micro Devices (AMD), Fairchild, Intel and National Semiconductor. If the AMD devices are successful in beta tests next summer, initial semi-proprietary FDDI products will reach the market by the third or fourth quarter of 1989.

INTERACTIVITY REPORT

Videotel Will Connect With France's Minitel

U.S. Videotel (USV) customers in Houston will be able to log onto about 1,500 services of the French Minitel network, thanks to a deal between USV and France Telecom, an arm of the French PTT. The arrangement, which uses the USV host computer as a gateway bridge to France's Minitel system, makes it possible for U.S. customers to see about one-third of the Minitel service, with more features due to be added later this year.

USV customers in Houston (and other cities when USV expands) will reach the French on-line system by typing "France" on the USV menu frame. Most USV customers will have a modified Minitel terminal, although USV is also distributing emulation software, making it possible for personal-computer users to access the system. USV is the exclusive distributor of French Minitel technology and terminals from Telic Alcatel.

USV plans to launch its Houston service this spring, offering telebanking, shopping, and on-line travel and information services such as Official Airlines Guides, American Airlines' Easy Sabre, and Associated Press news. USV President Amin Rahme says the company is "engaged in discussion with several Bell operating companies to identify prospects for joint market development." USV is involved in a market-research venture with Southwestern Bell.

In anticipation of the hookup to the U.S., segments of the French database are being translated into English, joining existing English-language material on Minitel, such as those produced by the British Broadcasting Corp., CBS News, and USA Today. The arrangement to make Minitel data available to USV customers is apparently the first in a planned series of "joint business and technology projects between USV and France Telecom," according to both parties. Details about additional ventures are not available. France Cables et Radio (a division of France Telecom) and USV are also exploring ways to make USV databases available to Minitel customers in France. For more information, contact U.S. Videotel, 5555 San Felipe Boulevard, Suite 1200, Houston, TX 77506. Telephone (713) 840-9777.

FOS²

Superfluorescent Fiber-Optic Signal Source Developed

The highest-power broadband signal confined to a single-mode fiber has been achieved in a joint research project between Stanford University and British Telecom's research laboratory. The researchers used a new solid-state superluminescent source with an output power greater than 10 milliwatts at 1,060 nanometers. The single-mode fiber used in this work was silica-based and was fabricated by an addition to the inside tube deposition method, they said.

Of the three major emission lines—about 900, 1,060, and 1,330 nanometers—only the 1,060-nanometer line was strongly self-absorbed and the 1,330 line was not detected. Therefore, 99 percent of the output signal consisted of the 1,060-nanometer emission. The coupling efficiency of the pump beam, not including the mirror loss, was about 70 percent. An output characteristic curve showed that, at low pump power, the output consisted almost entirely of spontaneous emission and that growth was occuring in a linear fashion at a low rate. As the pump power increased, the output became a mostly amplified spontaneous (or stimulated) emission. And it increased nonlinearly, as researchers expected.

BIOTECHNOLOGY

APPLIED GENETICS NEWS

National Institute of Health To Close Loophole

Since the 1986 test in Argentina of a genetically engineered rabies vaccine, undertaken by the Wistar Institute of Philadelphia, Penn., and the Centro Panamericano de Zoonosis, there has been some controversy over overseas testing. In this case, the test was undertaken without the knowledge of the Argentinian government or the U.S. National Institute of Health (NIH), which paid more than $3 million for the vaccine's development. The Argentinian government's reaction was to stop the experiment, kill the vaccinated cows, and take the local sponsoring organization to court.

The NIH ruled that Wistar had not violated guidelines for testing recombinant DNA molecules, because NIH funds were not used to take the vaccine abroad.

The situation has now changed. In February, an NIH panel moved to close the loophole. An ad hoc working group of NIH's Recombinant-DNA Advisory Committee (RAC) proposed that the NIH guidelines cover foreign as well as domestic field tests of gene-spliced products developed under NIH grants, if the research is a direct extension of the development process, and whether or not NIH money pays for the tests.

The RAC panel received its present task in September 1987, but was spurred into reaching a decision or proposal by recent events. The panel learned that some of the animal handlers involved in the vaccine experiment showed signs of viral infection. According to the Argentine government, the serological studies done on 17 people who had different degrees of exposure and contact with the inoculated cows suggested that the handlers have developed antibodies against the rabies virus.

In the test, unpasteurized milk from the inoculated cows was consumed by caretakers, a possible explanation for the caretakers' infection with the vaccine virus, which was not the rabies virus itself. The gene for rabies virus antigens had been spliced into a relatively benign host, the vaccinia virus—the original vaccine for smallpox.

None of the workers showing antibodies to rabies virus have come down with rabies, which means the vaccine virus probably has conferred immunity to the disease.

In its proposal, the RAC committee proposed language that would bring NIH guarantees under the guidelines even if NIH funds are not used to support the overseas experiment itself. The guidelines would apply, as they currently do, to projects done abroad if they are supported by NIH funds. In addition, they would apply to research done abroad if it involved deliberate release into the environment or testing in humans of materials containing recombinant DNA developed with NIH funds, and the research is a direct extension of the development process.

The proposal will be published in the Federal Register and, along with any comments generated, taken up by RAC at its next meeting. RAC's suggestion to change the guidelines will be submitted to the NIH director for approval. If approved, they will affect biotechnology companies that have voluntarily adopted the NIH guidelines as well as research institutes like Wistar. The FDA also expects compliance with the NIH guidelines by companies applying for marketing licenses for new gene-spliced vaccines or drugs.

California's Genentech Develops Protein That May Block AIDS Virus

Scientists at Genentech Inc. of South San Francisco, Calif., have cloned a natural protein that in the test tube appears to block infection by the virus that causes AIDS. The protein, called CDU, was produced in

genetically engineered mammalian cells and tested with the virus in cell culture, where the company said it "virtually abolished the growth of HIV-l," the AIDS virus.

The substance still faces months to years of animal and human testing before any potential benefits to AIDS patients can be determined. In its natural form, the protein normally is found on the outside of T4 cells, which are a type of T cell, one of the body's defenses against disease. These cells are selectively targeted and killed by the fatal virus. When the virus seeks out its targets, a protein on its outer coat binds to CDU protein on the T4 cells—a key step in infection.

ARTIFICIAL INTELLIGENCE

AI TRENDS

Texas Instruments' Mac Attack on AI Industry

Although Texas Instruments' introduction of microExplorer is certainly not the greatest thing to ever happen in artificial intelligence (AI), it is certainly one of the most eventful in that it has managed to galvanize a large part of the existing AI vendors into supporting it. TI is smart on their part, just as embracing the 80386 microprocessor (used in IBM's PS/2 machines) was a smart idea. Apple's Macintosh II is a consumer machine that is very capable of engineering, design, and graphics tasks. Supporting the microExplorer/Mac II opens a whole new world to the large expert-system vendors who have seen their LISP markets erode from market saturation and Symbolics' stumbling. Not since a sizable cross section of the AI industry supported the brain-dead IBM RT-PC has a single architecture managed to infuse a spark of marketing sense in AI vendors.

Many will probably think of the Macintosh in the little boxy form that it was introduced in, and still retains in its Mac SE and Mac Plus configurations. The current Mac II bears more resemblance to Sun workstations than to older Macs. Plus, the Macintosh II was developed using the Nu-Bus architecture, which was the basis for Lisp Machine's Lambdas and TI's Explorers. Although developed at MIT, the Nu-Bus license is owned by TI—which is where Apple got it in the first place.

The significant thing about the TI and Apple agreement is simply the realization that if LISP machines are to continue to sell, they must sell as integrated parts of mass-market (or marketable) machines. Not only do purchasers of the microExplorer get the LISP environment, but they get access to the Macintosh software environment, Apple's AUX Unix system, the MS-DOS environment, as well as Apple's highly touted recent hooks into the DEC VAX world. Granted, most of these capabilities are only available as board additions and modifications to the Mac II, but it all subscribes to the practice of having one machine capable of doing many things (Sun's theory), as opposed to one machine which is really designed to do only one thing.

One disadvantage to all of this at the outset is that Texas Instruments is handling all of the sales and marketing. TI may have been able to come up with a slick little LISP machine, but its success in selling hardware of any kind in the past has not been illustrious by any stretch of the imagination. In fact, TI's hardware selling debacles have been chronicled here as well as in many other publications. Apple is going to "watch and see" how TI does, but it better not hold its breath. And while this may be a reaffirmation of the LISP environment, it still is going to be an uphill battle to sell these machines into new customer sites. It may be easy to put the microExplorer into existing sites where users have been waiting for true LISP-based computers that didn't cost an arm and a leg. New users will still have to be convinced of the machine's appeal, although having access to most of the major expert-system development tools can certainly help. TI also claims that, upon the introduction of the machine, a non-LISP machine customer was swayed into buying quite a few microExplorers as a way to get into LISP development.

The microExplorer also lacks a lot in the power department, in some cases running less than 50 percent the speed of an Explorer or Symbolics machine. TI claims that this was necessary in order not to burn out the Mac's power supply. Plus, there will be some screen sacrifices when running programs like ART, KEE, and Knowledge Craft, due to the design of the Mac's display controller. All programs operate on the Mac through the Explorer window on the screen, so their interfaces

do not have to be modified to meet Apple's required specification for Macintosh applications.

The next few months will be crucial not only for TI, but for Apple, Symbolics, and all LISP vendors. The microExplorer holds the key to TI's immediate AI hardware future. The venture is Apple's first test of AI waters and the Macintosh II is the machine that the Symbolics 3610AE never was. Its acceptance or rejection could very easily affect the continued commercial use of LISP.

MANUFACTURING AUTOMATION

Flexible Automation

Westinghouse Sets New Course

Large companies with strong traditions have trouble regrouping to serve new and initially often nebulous markets. Westinghouse is no exception.

The company has both automation products and remarkable installations that apply automation—the electronic assembly facility at College Station, Texas, for example, with its follow-on in Baltimore. Westinghouse also has major flexible manufacturing systems (FMS) for use both in house and also by outside customers such as General Dynamics and LTV.

Westinghouse has found it hard to fuse its products and experience into a cohesive effort. But now the mood is definitely upbeat. Over the past few years, the company has regrouped its automation activities into an organizational structure intended to reflect target markets. In addition, the company has created a product strategy that includes Puma and gantry robots.

Robots are now a profitable Westinghouse activity, thanks in part to the manufacture of robot arms in England and electronic controls at a modern U.S. facility that consolidates production of many Westinghouse controls.

The keystone to present company strategy is an effort to drive up-front engineering costs down by reusing as much computer code as possible. Automation projects (robotic or FMS) wither under the cost of software development. Modular packages are the goal. However, total modularity, where you can pluck a dozen packages off the shelf and string them together, is beyond today's capabilities. Thus, Westinghouse is placing emphasis on interface definitions that can reduce requirements for custom code by 40 percent to 80 percent.

In its reorganization, all Westinghouse automation activities fit under a Factory Automation Products and Systems canopy. Beneath the canopy sits the Automation Division, for discrete parts manufacturing. This division includes Numalogic programmable controls, Unimation with its robots, and a systems group. Westinghouse has close ties with Digital Equipment Corp. and often uses DEC's relational-database management systems, artificial intelligence, and Ethernet products.

The restructured organization has been developing new products, including a new Unival robotics control, an advanced version of the Series 6000 robot, and a flexible manufacturing control system known as MRS. Westinghouse is moving away from the automobile industry into aerospace and electronics and is looking around for alliances and acquisitions.

The proposed creation of a 50/50 joint venture with Japan's Matsushita to market automation globally now appears doomed. But final touches are being put on a nonexclusive agreement with Matsushita for incorporating the new Unival control in its Panarobo assembly robot.

Radio Tags Keep Track of Inventory

Many studies have shown that products and materials spend a huge portion of their time at the manufacturing site either in storage, queue, or moving from one operation to another. The high cost of keeping product far longer than its processing time is apparent in inventory carrying costs.

Another cost associated with materials handling and storage can also contribute significantly to manufacturing costs: overhead in personnel time. Locating and retrieving materials and products often requires considerable time from direct labor personnel as well as stock and materials clerks. Schedulers, planners, and manufacturing supervisors may also be tied up in these materials movement and location activities.

Even if these activities are minimized, verifying that the materials located or moved are actually those

needed can consume even more time. As manufacturing lot sizes become smaller, the need to identify each individual product becomes more important.

Automatic identification (A/ID) systems often provide a key to automating manufacturing processes. These systems mark materials and products in such a way that machines can distinguish them, allowing materials movement through a process without undue human handling and intervention. Although nearly every manufacturing organization spends considerable time on tracking products and materials, in the ideal no-waste factory, those operations would be eliminated because they add no value to the product.

The most common form of A/ID for materials tracking is bar-code systems, but another technology is beginning to find favor for applications in which bar codes are not practical or reliable: radio frequency identification (RF/ID). Instead of a printed label, which must be read optically and might be damaged in handling and movement, RF identifiers are tags, or tiny radio receivers and transmitters, which vary from the size of a grain of rice to that of a cigarette pack. RF systems can be very simple and low cost, or intelligent and expensive.

The advantages of RF/ID over bar codes allows them to be used in applications where automatic ID is not feasible. For example, because RF systems are not limited to line-of-sight, a container or product or even dirt can cover the tag and still produce a reliable reading. This also means that the tags are impervious to dirt or other coverings.

Another potential application involves using the read-write ability of some tags to add new data to a product's tag as it moves through a process. New or different information about status, contents, revision level, test results, or condition can be added for process as well as product tracking.

Other advantages of RF tags include the ability to store from eight bits to thousands of characters, an operating range (distance from the identifier to the reading device) that exceeds that of bar-code or other identification systems, and the fact that RF tags are more difficult to counterfeit than bar-code labels.

In addition, some tags include a microprocessor, which allows the device being tracked to access computers, make calculations, carry information, and make decisions. These capabilities reduce the demands on controlling computers—a significant consideration if every product or material unit causes certain computational tasks to occur.

Networks, Laser Drives Debut

OFFICE PRODUCTS

FO-300 fax machine. Sends a facsimile document in 18 seconds; handles originals as large as 11×17 inches. The machine includes a 16-tone gray scale for transmitting photos and half-tone images, plus a four-page memory for receiving confidential documents. Works with other Sharp fax machines in a network. $1,995. Sharp Electronics Corp., Sharp Plaza, Mahwah, NJ 07430. (201) 529-8950. *Circle 1.*

3+Mail electronic-mail software. Version 1.3 lets users transfer electronic mail among various workstations and across different networks. Runs on IBM-compatible computers and on the Macintosh Plus, SE, and II. $595 for a five-user system. 3Com, 3165 Kifer Rd., Santa Clara, CA 95052. (800) 638-3266; in Calif., (408) 562-6400. *Circle 2.*

4045 Laser CP printers. Two models produce 10 pages/minute and have a 750-sheet feeder/stacker that can interweave paper stocks. Both have one megabyte of memory and print 15,000 pages/month. Model 150 costs $4,995; Model 120, $6,495. Xerox Corp., Box 24, Rochester, NY 14692. (800) 832-6979. *Circle 3.*

8200HP interface card. Lets Hewlett-Packard LaserJet II printers work with IBM System/36 or System/38 minicomputers. The card automatically selects the appropriate font and permits 80-, 132-, or 198-column printing. $995. I-O Corp., 2256 South 3600 West, Salt Lake City, UT 84119. (801) 973-6767. *Circle 4.*

Comet portable fax machine. This model includes an automatic document feeder and sends a page in less than 20 seconds. The 8.8-lb. device connects to a personal computer and measures about 12×12×3 inches. Works with Group II and III facsimile machines. $1,699. Comet Corp., 745 High St., Westwood, MA 02090. (800) 553-5013; in Mass., (617) 244-8553. *Circle 5.*

Gold Express laser printer. This printer delivers eight pages/minute with 300-dot/inch resolution and offers 1.5 megabytes of memory and 31 standard typefaces. It emulates the Hewlett-Packard 7475A plotter and LaserJet Plus, as well as the Diablo 630, Epson FX-80, NEC Spinwriter 3550, and other printers. $3,695. Office Automation Systems Inc., 9940 Barnes Canyon Rd., San Diego, CA 92121. (619) 452-9400. *Circle 6.*

Harvard Elite speaker phone. Works with any digital or four-wire phone system; provides the proper audio delay for satellite-link conversations. From $425. A.T. Products Inc., Box 625, Harvard, IL 60033. (815) 943-3590. *Circle 7.*

ICD telephone system. This call-distribution system, which works with the company's Automated Attendant Exchange phone systems, tells callers the estimated time they will spend on hold and the number of calls ahead of them. The system prevents more than 20 callers from being placed on hold. $20,000 to $50,000. Dytel Corp., 50 East Commerce Dr., Schaumburg, IL 60173. (312) 519-9850. *Circle 8.*

ILAN-1 network-integration system. Links multiple networks and communication links into a single system. One chassis supports four Ethernet and StarLAN networks in any configuration. $4,575 to $10,850. Crosscom Corp., Box 699, Marlborough, MA 01752. (617) 481-4060. *Circle 9.*

ITCS phone-billing software. These 10 programs process as many as three million call records per month for 24 sites. The software automates voice and data equipment and helps manage networks by maintaining circuit-configuration databases and equipment for as many as 24,000 stations. Also helps control inventory. $20,000 to $90,000. Aud-Cyn Associates Inc., 1259 Route 46, Parsippany, NJ 07054. (201) 334-4042. *Circle 10.*

Message Center software. Lets telephone-message centers record calls on personal computers. The package handles conference scheduling and helps create inventories and work-order requests. $8,850 for minicomputers, $2,500 for personal computers. Multi-Tek Software Corp., 1500 Planning Research Dr., McLean, VA 22102. (703) 556-1093. *Circle 11.*

Model 4001 shredder. Handles paper, cards, plastic film, and light metal plates through its 16-inch opening. The device automatically shuts off to prevent jams. $2,845. A $3,595 cross-cutter version shreds a sheet into more than 2,000 pieces. Michael Business Machines, 54-21 48th St., Maspeth, NY 11378. (800) 223-2508; in N.Y., (718) 482-8610. *Circle 12.*

Model 6475 laser printer. This model prints 12 pages/minute and has two megabytes of memory for high-volume mailings, spreadsheets, labels, reports, and graphic presentations. Handles 10,000 pages/month; holds 750 sheets of paper. From $4,195. Data General, 4400 Computer Dr., Westborough, MA 01580. (800) 328-2436; in Mass., (617) 366-8911. *Circle 13.*

PC Payroll software. Part of the BusinessWorks series; runs under MS-DOS or PC-DOS to help calculate earnings, benefits, and taxes. The program keeps track of hiring dates, sick leave, vacations, and wage histories for any number of employees. Produces W-2 and W-3 forms. $295. Manzanita Software Systems, 1 Sierragate Plaza, Suite 200-A, Roseville, CA 95678. (800) 531-3552; in Calif., (800) 447-5700. *Circle 14.*

PFR Macintosh slide-maker. Makes slides from Macintosh computers, using a software driver for color or black-and-white images in Mac PICT format. The device offers 4,000-line resolution and works with the Macintosh II, Plus, and SE via the Small Computer Systems Interface (SCSI). $4,995. Lasergraphics Inc., 17671 Cowan Ave., Irvine, CA 92714. (714) 660-9497. *Circle 15.*

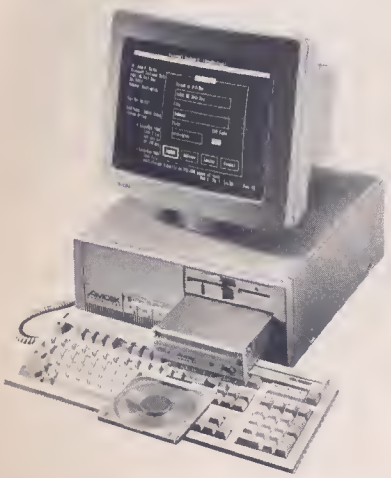
Summit 3000 multiuser computer. This 80386-based system supports 32 users and is compatible with the IBM PC/AT. The base configuration offers a 12-slot bus, one megabyte of memory, and a 300-watt power supply. A typical nine-user system with a ¼-inch-tape drive and a 1.2-megabyte disk drive costs $22,510. Rexon Business Machines, 5800 Uplander Way, Culver City, CA 90230. (800) 421-5184; in Calif., (213) 641-7110. *Circle 16.*

Teledoll-Plus phone-cost program. Calculates which of 29 long-distance services will save a company the most money. Users enter a month's worth of calls into the MS-DOS program, which is made for businesses that have long-distance phone bills of $1,000 to $10,000 per month. $89.95. Suresoft Inc., 1311A Dolley Madison Blvd., McLean, VA 22101. (703) 893-6100. *Circle 17.*

Triniscope video projector. Takes images from television or other cathode-ray-tube displays, using a condensing lens to add brightness and improve resolution, contrast, and color. Resolution is 1,280 lines. The projector creates images measuring 2 to 25 feet. $18,500. Triuniplex Display Systems, 50 West Easy St., Simi Valley, CA 93065. (805) 526-4650. *Circle 18.*

Tru Simplicity phone-use monitor. Provides accounting and billing information for telephone systems with as many as 250 lines. The device handles 30,000 call records and monitors how each phone is used. Includes password security, a membrane keypad, a liquid-crystal display, and an eight-hour backup battery. Price varies with configuration. Nynex Business Information Systems, 65 West Red Oak Lane, White Plains, NY 10604. (800) 346-9999; in N.Y., (914) 683-2932. *Circle 19.*

COMPUTER HARDWARE



Laserdek 1000 CD-ROM drive. This half-height drive fits in the floppy-drive slot of the IBM PC and compatible computers. Provides simultaneous access to text, audio, and graphics. The unit has an interface card, a device driver, audio software, cable, and MS-DOS CD-ROM extensions. A headphone jack is also included. $895. Amdek Corp., 1901 Zanker Rd., San Jose, CA 95112. (408) 436-8570. *Circle 20.*

3D Engine graphics board. Turns an IBM PC/AT or compatible machine into a workstation for computer-aided design. The board transforms 5,000 constant-shaded, 500-pixel polygons per second and writes 40,000 two- or three-dimensional vectors per second. Includes two megabytes of memory. $5,995. Nth Graphics, 1807-C West Braker Lane, Austin, TX 78758. (800) 624-7552; in Tex., (512) 832-1944. *Circle 21.*

525GB optical drive. An internal, 1.2-gigabyte, write-once read-many (WORM) optical-drive subsystem for the IBM PC/XT/AT and compatible computers. The drive transfers data at 6.5 megabits/second and includes a controller, software, and cables. $5,988. Information Storage Inc., 2768 Janitell Rd., Colorado Springs, CO 80906. (303) 579-0460. *Circle 22.*

AppleCD-SC CD-ROM drive. Plugs into Macintosh Plus, SE, and II computers through the Small Computer Systems Interface. The drive has a 64-kilobyte memory buffer, a headphone jack, two RCA jacks, and a universal power supply. Includes an audio chip set and software to play audio compact discs. $1,199. Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014. (408) 996-1010. *Circle 23.*

CD Net/Server network drives. These drives connect CD-ROM drives and databases to Token Ring, Ethernet, and Arcnet local-area networks. CD Net connects small to medium networks; CD Server connects medium to large networks. Both support Novell and MS-NET software. CD Net costs $2,995; CD Server is $5,995. Meridian Data Inc., 4450 Capitola Rd., Suite 101, Capitola, CA 95010. (408) 476-5858. *Circle 24.*

CN4551 color monitor. A 14-inch display compatible with the IBM PC/XT/AT as well as IBM's PS/2 VGA and PGA standards. The monitor has 720×480-pixel resolution, RGB analog and TTL signal inputs, and a tilt-and-swivel stand. $749.95. Samsung Electronics, 301 Mayhill St., Saddle Brook, NJ 07662. (201) 587-9600. *Circle 25.*

D-Link Ethernet adapter card. This half-sized card connects IBM PC/XT/AT and compatible computers to an Ethernet local-area network. The card moves data at 10 megabits/second and has a transceiver to work with RG-58 A/U thin cable. Compatible with Novell's NE-1000 Ethernet card. $369. Localnet Communications Inc., 3303 Harbour Blvd., Suite E-8, Costa Mesa, CA 92626. (714) 549-7942. *Circle 26.*

FreezFrame image-capture board. This board equips the IBM PC/XT/AT and compatible computers to capture real-time images from a video camera, VCR, laser-disc player, or any NTSC source. Lets the computer superimpose EGA/CGA text and graphics on images in 32,768 colors with a resolution of 512×256 pixels. $1,749. VuTek Systems Inc., 10855 Sorrento Valley Rd., San Diego, CA 92121. (619) 587-2800. *Circle 27.*

Jumbo tape-backup system. Acts as an internal or external drive for the IBM PC/XT/AT, PS/2, and compatible computers. Holds 40 megabytes, and will accept 60-megabyte DC 2000 tape cartridges when they become available. The system's software supports Novell and 3Com networks. Less than $300. Colorado Memory Systems Inc., 800 South Taft Ave., Loveland, CO 80537. (303) 669-8000. *Circle 28.*

Lancard E-II adapter board. Connects IBM's PS/2 Models 50, 60, and 80 to Ethernet local-area networks operating at 10 megabits/second. The board is compatible with Novell Netware and other local-area-network software and uses Ethernet cables. $725. Tiara Computer Systems Inc., 2700 Garcia Ave., Mountain View, CA 94043. (415) 965-1700. *Circle 29.*

Modular Multiport board. A serial-port board that connects terminals and printers, via RJ-11 telephone-style connectors, to multiuser systems running MS-DOS. Compatible with Unix, Xenix, Pick, PC-MOS/386, and PC-DOS operating systems. The eight-port board handles data at 56 kilobits/second. $595. Arnet Corp., 618 Grassmere Park Dr., Suite 6, Nashville, TN 37211. (800) 366-8844; in Tenn., (615) 834-5222. *Circle 30.*

ND356T drive and installation kit. Puts a 3½-inch floppy-disk drive in an IBM XT/AT or compatible computer made for a 5¼-inch drive. The drive holds 1.44 megabytes of formatted data. $219. An optional $14.95 software driver suits the drive for DOS versions 2.0 to 3.1. Toshiba America Inc., Disk Products Department, 2001 East 4th St., Suite 120, Santa Ana, CA 92705. (714) 954-1125. *Circle 31.*

QIC-File Plus tape backup. This backup system holds 60 megabytes of data from the IBM PS/2 Model 50, 60, or 80 on one ½-inch tape cartridge. Allows automatic backup; compatible with Novell Netware. Measures about 2×6×8 inches. $995. Sysgen Inc., 556 Gibraltar Dr., Milpitas, CA 95035. (408) 263-4411. *Circle 32.*

QuadHPG graphics board. Converts the IBM PC/XT/AT or compatible computers into graphics workstations. The board draws at 2.5 million pixels/second and has 640×480-pixel resolution with eight planes of color. Displays 256 colors simultaneously from a palette of 16.7 million. $995. Quadram, 1 Quad Way, Norcross, GA 30093. (404) 923-6666. *Circle 33.*

RHC-88 hand-held computer. A 16-bit, MS-DOS-based computer with 512 kilobytes of memory (expandable to one megabyte). The unit has a backlit, liquid-crystal display and an alphanumeric keyboard. Measures about 9×6×3 inches; weighs 4.5 pounds. Has RS-232C and optical-communication ports. Meets military standards for ruggedness. $3,995. Paravant Computer Systems, 7800 Technology Dr., Melbourne, FL 32904. (305) 727-3672. *Circle 34.*

Tophat II memory board. Gives the IBM PC/AT and compatible computers an additional 128 kilobytes of memory. Has six memory chips; works with both MS-DOS and OS/2 operating systems. $145. Boca Re-

search Inc., 6401 Congress Ave., Boca Raton, FL 33431. (305) 997-6227. *Circle 35.*

Turbo Plus personal computer. Built around an 80386 processor running at 16 or 20 megahertz, with two megabytes of memory. Includes a 65-megabyte hard disk, a 1.2-megabyte disk drive, eight expansion slots, and a 14-inch monochrome monitor, plus serial, parallel, and game ports. $3,299. TBS International, 20 Main St., Ashland, MA 01721. (617) 881-7322. *Circle 36.*

COMPUTER SOFTWARE

Clear for dBase documenter. Reads the source code of any dBase application and automatically produces the system tree, program flow charts, and formatted source listings. The program also calculates spacing, required pages, and flow-chart symbol placement for printing. Works with the IBM PC/XT/AT and compatible computers. A dot-matrix-printer version costs $99.95; a laser-printer version is $149.95. Clear Software Inc., 637 Washington St., Suite 204, Brookline, MA 02146. (617) 232-4720. *Circle 37.*

Charitable Scenario tax planner. Calculates the effects of donations on the contributor's taxes; generates reports for various types of donations. $2,495. PhilanthroTec Inc., 6135 Park Rd., Suite 109, Charlotte, NC 28210. (704) 554-1646. *Circle 38.*

Concordance text retriever. Finds text without requiring users to specify the location of data. The program uses pull-down menus, stores one million pages of text, and includes a word processor. Runs on computers using MS-DOS 2.0 or later versions. $295. Dataflight Software, 10573 West Pico Blvd., Suite 68, Los Angeles, CA 90064. (213) 785-0623. *Circle 39.*

DataSafe security system. Encrypts files stored on personal computers running MS-DOS 2.0 or later versions. The software completely deletes obsolete files from the hard disk and encrypts backup copies stored in remote locations. $49. Az-Tech Software Inc., 305 E. Franklin, Richmond, MO 64085. (800) 227-0644; in Mo., (816) 776-2700. *Circle 40.*

DocuComp document comparer. This MS-DOS program compares two versions of a document and highlights revisions. It shows inserted, deleted, replaced, and moved text when printing a comparison, and can compare documents created on different word processors. $149.95. Advanced Software, 1095 East Duane Ave., Suite 212, Sunnyvale, CA 94086. (408) 733-0745. *Circle 41.*

Font Editor typeface/logo maker. Lets users modify characters to create typefaces and images. The program provides 1,500 characters and symbols for editing. Runs on computers with a graphics card, 450 kilobytes of memory, and DOS 2.0 or later versions. $290. SoftCraft Inc., 16 North Carroll St., Suite 500, Madison, WI 53703. (800) 351-0500; in Wis., (608) 257-3300. *Circle 42.*

Full Impact spreadsheet. This Macintosh program includes word processing, macro language support, import/export capability, and formatting for desktop publishing. $395. Ashton-Tate, 20101 Hamilton Ave., Torrance, CA 90502. (213) 329-8000. *Circle 43.*

FullWrite word processor. Combines desktop-publishing and graphics capabilities with word-processing software, including page-layout and drawing abilities. $395. Ashton-Tate Corp., 20101 Hamilton Ave., Torrance, CA 90502. (213) 329-8000. *Circle 44.*

Fundamentals typeface packages. These three desktop-publishing packages combine typefaces that work well together for specific types of documents—one suits newsletters, another fits books and manuals, and the third creates flyers. Each package has three type fonts. $395 each. Bitstream Inc., 215 First Street, Cambridge, MA 02142. (617) 497-6222. *Circle 45.*

NLQ translator. Translates English commands into the query language of mainframe database-management systems. Transfers data from the mainframe to a personal computer and presents data as tables. The program runs on the IBM PC and compatible computers with 512 kilobytes of memory and an asynchronous communications port. $500. Battelle, 505 King Ave., Columbus, OH 43201. (614) 424-6424. *Circle 46.*

COMMERCIAL/INDUSTRIAL

QPC-7000 computer. A rugged IBM PC/AT-compatible machine that fits in a standard 19-inch rack. Includes a 20- or 40-megabyte hard disk and a disk drive that holds 360 or 720 kilobytes or 1.2 megabytes. In addition, the computer provides EGA or VGA graphics adapters, one serial and one parallel port, 11 expansion slots, and a 200-watt power supply. From $2,790. Qualogy Inc., 2241 Lundy Ave., San Jose, CA 95131. (408) 434-5200. *Circle 47.*

CamCamera 201 measuring camera. This computer-aided device measures stationary or moving objects by calculating the X/Y coordinates of five markers. The digital camera has a maximum sampling rate of 15 frames per second and works with DOS-based computers or the Apple II. Includes camera, lens, cable interface card, and software. $995. DigitEyes Inc., 120 Ashley Rd., Clemson, SC 29631. (803) 654-9352. *Circle 48.*

DDK-78310 computer-test kit. Helps evaluate the uPD78000 line of real-time microcomputers. Includes an evaluation board, an on-board monitor, an RS-232C serial interface, and eight kilobytes of memory. The kit addresses as much as 64 kilobytes of external memory. $312. NEC Electronics Inc., Box 7241, Mountain View, CA 94039. (415) 960-6000. *Circle 49.*

Induction plasma system. Processes large particles for rapid-solidification studies. Users inject particles with diameters as large as 1,000 microns into a three-inch-diameter core of plasma. This core has a residence period 70 times that of other plasma systems, according to the company. The system operates on oxidizing, reducing, inert, or reactive gases and heats plasmas to 15,000° Fahrenheit. $250,000 to 600,000. Tafa Inc., Box 1157, Concord, NH 03301. (603) 224-9585. *Circle 50.*

Ltime critical-path analyzer. This software identifies transistor-level critical paths, optimizes critical-path transistor sizes, and estimates dynamic power consumption for integrated circuits. The system sorts through input/output paths, paths through intermediate nodes, and paths whose delays fall within a user-specified time interval. A rule checker identifies potential design errors. $40,000; $25,000 as an option on the company's GDT and Lsim chip-design products. Silicon Compiler Systems Corp., 2045 Hamilton Ave., San Jose, CA 95125. (408) 371-2900. *Circle 51.*

Micro-Optical pyrometer. Measures the temperature of objects as small as 0.0005 inches in diameter, including cathodes, filaments, and wires. Also checks furnace temperatures during crystal-growth procedures and other processes. Covers 1,292° to 5,792° Fahrenheit. $2,178. Pyrometer Instrument Co. Inc., 234 Industrial Parkway, Northvale, NJ 07647. (800) 468-7976. *Circle 52.*

MID manufacturing software. Simplifies complex illustrations by merging computer-aided design and manufacturing instructions and technical graphics. The program works with process-planning and word-processing programs and can print out, update, or display instructions on shop-floor terminals. $40,000 to $150,000. Palette Systems Inc., 2 Burlington Woods Park, Burlington, MA 01803. (617) 273-5660. *Circle 53.*

NVF photoplotter interface. This compressed-binary software option for the com-

pany's computer-aided design and manufacturing workstations supports complex pad geometries and eliminates the need to build new aperture setup tables. Available on nine-track tape or as a Sun-format cartridge. $1,500. Cadnetix, 5775 Flatiron Parkway, Boulder, CO 80301. (303) 444-8075. *Circle 54.*

R1200 digital scope. Analyzes transient, vibration, modal, audio, and physiological waveforms on a personal computer. The unit offers 12-bit analog-to-digital conversion on each of its two channels, a 64-kilobyte data buffer, and a sampling rate of 1 hertz to 1 megahertz. $2,995. Rapid Systems Inc., 433 North 34th St., Seattle, WA 98103. (206) 547-8311. *Circle 55.*

Strantrol controllers. Series 740 units control conductivity, Series 750 devices handle oxidant/reductant, and Series 730 controllers monitor pH levels. All use light-emitting diodes to indicate chemical levels; the diodes flash to warm of overfeed. $725 to $795. Stranco, Box 389, Bradley, IL 60915. (815) 932-8154. *Circle 56.*

■ CONSUMER PRODUCTS

Quicksnap Flash disposable camera. A film package with a lens, a 1/100-second shutter, and an electronic flash. It exposes 24 frames of Fujicolor HR 400 35-millimeter film. $13.95. Fuji Photo Film U.S.A. Inc., 800 Central Blvd., Carlstadt, NJ 07072. (800) 345-6385. *Circle 57.*

B250 programmable amplifier. Lets users specify stereo, mono, or a blend; set levels for all source inputs; adjust three phono inputs; and define power limits to protect two separate speaker systems. The unit offers three levels of heat protection and a nonvolatile memory to save programming during power loss. Delivers 150 watts/channel. $2,000. Studer Revox America Inc., 1425 Elm Hill Pike, Nashville, TN 37210. (615) 254-5651. *Circle 58.*

B260 tuner. Has 60 FM-station presets that users can group by program type. Provides a calibration tone, automatic tuning, and two programmable antenna outputs. The tuner filters out unwanted sidebands and extraneous frequencies to ensure a clear signal. $2,000. Studer Revox America Inc., 1425 Elm Hill Pike, Nashville, TN 37210. (615) 254-5651. *Circle 59.*

DAC2000 DAT player. This car unit plays digital audio tapes (DAT) and offers two-channel sound. The unit plays both prerecorded and home-recorded tapes and rewinds tapes 200 times faster than it plays them; a 120-minute tape rewinds in about 40 seconds. $1,799.95. Clarion Corp. of America, 5500 Rosecrans, Lawndale, CA 90260. (213) 973-1100. *Circle 60.*

Quad sound decoder. Produces three-dimensional sound through a stereo system by decoding and separating recording elements. The 1½×4×1-inch device connects to the amplifier and requires a system with four speakers. $18.95. Quant-m Corp., Box 250, East Amherst, NY 14051. (716) 688-6377. *Circle 61.*

VR97-series VCRs. Model VR9720 offers a 38-function remote controller, on-screen function displays, and one-touch timed recording. The VR9722 adds bar-code programming and an expanded automatic-recording timer. The Model VR9730, a three-head recorder, produces clear freeze-frame images and has a 43-function remote controller. The VR9740 has four heads and offers extra-slow motion and searching abilities. $399.95 to $449.95. Philips Consumer Electronics Corp., Box 14810, Knoxville, TN 37914. (615) 521-4316. *Circle 62.*

VRE150 three-head VCR. Provides five-speed slow motion and uses double-azimuth tape heads for clear freeze-frame images. Has a 157-channel quartz-electronic tuner and lets users automatically search for taped programs. Also offers wireless remote-control and circuitry for detail enhancement. $399. Zenith Electronics Corp., 1000 Milwaukee Ave., Glenview, IL 60025. (312) 391-7000. *Circle 63.*

Z-30 lightweight copier. This portable unit measures 15×17×5 inches and weighs less than 25 pounds. It prints five copies/minute and can copy nine sheets continuously. The paper tray holds 50 sheets; warmup takes 20 seconds. Less than $1,000. Sharp Electronics Corp., Home Office Electronics Division, Sharp Plaza, Mahwah, NJ 07430. (201) 529-8874. *Circle 64.*

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NEW COMPANIES

COMPANY	BUSINESS OBJECTIVE	FINANCING	OFFICERS	OFFICERS' PREVIOUS POSTS
American Capital and Research 9300 Lee Highway Foirfox, VA 22031 (703) 934-3000	To serve os a holding campany far ICF Inc., Health ond Sciences Research Inc., Phase Linear Systems Inc., American Venture Investments Inc., and ICF Consulting Assaciates Inc.	Employee owned; undisclosed funds from employees	James Edwards, chairman, president Richard Darman, director	ICF Inc., chairman, CEO Shearson Lehmon Huttan, mng. director (current)
Continental Circuits 3502 E. Roeser Rd. Phoenix, AZ 85040 (602) 268-3461	To monufacture surface-maunt, multiple-layer circuit boords.	$18 million in first round (AMEX: CKT)	Michael Flatt, choirmon Jahn Carr, president, CEO, directar	Continental Circuit Carp., president Orange Nossou Electronics, president, CEO
Dialogue 800 Hingham St., N-2 Rocklond, MA 02370 (617) 871-8400	To sell, install, and maintain voice and coll-processing systems that use saftware modules an personal computers.	Undisclosed private funds	Parker Lodd, choirman, CEO Jerry Confer, president	Lon-Tel, executive v.p. Lan-Tel, v.p. sales
Epoch Systems 313 Bastan Post Rd. W. Marlboraugh, MA 01752 (617) 481-3717	Ta design, produce, ond morket high-capacity data storage and management systems for 32-bit graphics workstatians.	First-round funds from Charles River Partners, Matrix Partners	Kenneth Holberger, president Donald Byrne, v.p. sales & marketing	8ytex, v.p. engineering Digital Equipment Corp., mgr. OEM morketing
Halley Systems 2811 Orchard Pkwy. Son Jose, CA 95134 (408) 434-3500	To develap and market links for locol- and wide-orea networks.	Whally owned subsidiary of CCT Corp. of San Diego	Zvi Alan, president Robert McKay, chairman	Ivy Communicatians, president Infomag, CFO
Intl. Communication Services 189 Wells Ave. Newton, MA 02159 (617) 332-7243	To provide services to regional Bell aperating campanies and end users, including network design, engineering, equipment installation, and system integration.	$1 million in venture copital	Robert Kelsey, president Michael Musen, v.p.	8rintec, v.p. Murray Internotionol, program mgr.
Logic Modeling Systems 2880 Zonker Rd. Son Jose, CA 95134 (408) 922-0870	To develop, manufacture, and market advanced modeling software that simulates integrated circuits to check logic and detect faults.	Undisclosed funds from Sigma Partners and others	L. Curtis Widdoes, Jr., president, CEO Steve White, v.p. operatians	Valid Logic Systems, cofounder, v.p. Valid Logic Systems, v.p. monufocturing
Monolithic Instruments 8ox 341 Florissant, MO 63033 (314) 821-0776	To produce speciolized components for signol and infarmation processing, ond to simplify digital-signal-processing technology.	Undisclosed funds fram founders	Gregory Rice, president	Northrop Operatians, sr. engineer
NMB Technologies 9730 Independence Ave. Chatsworth, CA 91311 (818) 709-1770	To market electronic devices in Narth Americo for NM8 Audio Research Corp., NM8 Semiconductor Corp., NMB Hi-Tek Carp., and IMC Components Corp.	Wholly owned subsidiary of Minebea Co. of Tokyo, Japan	H. Robert Ishikawa, president William Connell, exec. v.p.	NM8 U.S.A., president (current) NM8 U.S.A., exec. v.p. (current)
Panasanic Factary Automation 1872 Brummel Dr. Elk Grove Villoge, IL 60007 (312) 952-1709	To design and develop factory systems and softwore and to market printed-circuit-board assembly systems, assembly robots, and measuring equipment.	Whally awned subsidiary of Matsushita Electric Corp. of America	Scott Minakami, president	Panasanic Industrial Co., exec. v.p. (current)
Primetime Saftware Box 27967 Santa Ana, CA 92799 (714) 556-6523	To develop and market personal-productivity software.	Undisclosed funds fram officers	Jack Waller III, president	Wisewore Inc., president

CONTRACTS AWARDED

AWARDED TO	AWARDED BY	AMOUNT	PURPOSE
Aerojet TechSystems 8ox 13618 Sacramento, CA 958S3 (916) 3SS-1000	U.S. Air Force Astronautics Laboratory (Edwards Air Force Bose)	$43 million	To develop concepts for spoce-based, non-nuclear defenses to destroy missiles obove the earth's atmosphere, os part of the Strategic Defense Initiative.
Aerojet TechSystems 8ox 13618 Sacramento, CA 958S3 (916) 3SS-1000	Rockwell International's Racketdyne Division	$S million	To install and test a prototype propulsion system for the Nationol Aerospace Plone.
Allied-Signal 252S West 190 St. Tarrance, CA 90S09 (213) S12-1006	U.S. Air Force Systems Commond (Wright Patterson Air Force 8ose)	$42.7 million	To develop cryogenic refrigeration systems for surveillance satellites.
AT&T 1200 Mt. Kemble Ave. 8asking Ridge, NJ 07920 (201) 9S3-7000	Telefanica (Spain's telephane company)	$6S millian	Ta install a Pencon-4 fiber-optic cable system between Spain and the Canary Islands.
AT&T 1200 Mt. Kemble Ave. 8osking Ridge, NJ 07920 (201) 953-7000	Xinhua News Agency, China	$2.8 millian	Ta connect the agency's departments in Beijing and allow them ta send electranic mail ta media arganizations warldwide.
Baeing 7980 8oeing Court Vienna, VA 22180 (703) 821-6000	U.S. Air Farce	$2.8 million	To conduct research into applying artificial intelligence to computer-aided design.
Baeing 79B0 Baeing Court Vienna, VA 22180 (703) 821-6000	U.S. Department of Education	$15 millian	To pravide infarmatian services far the department's Information Technology Services office, including computing services and technical suppart.
California Microwave 990 Almanor Ave. Sunnyvole, CA 94086 (408) 732-4000	AT&T	$5.2 millian	Ta pravide two satellite earth-stations for the Defense Cammercial Telecammunications Network (DCTN) government facility ond upgrade eight existing DCTN stations.
Centel Business Systems B72S Higgins Rd. Chicago, IL 60631 (312) 399-S160	NASA's Goddard Space Flight Center	$9.6 millian	Ta pravide suppart services, including the develapment of saftware for translating and retrieving infarmation from satellites.
Datapoint 972S Dotapoint Dr. San Antonio, TX 78284 (512) 699-4437	Italian Army's Judiciary Palice 8ranch	$2.7 million	To provide local-orea-network computer systems.
Eastman Kodak 343 State St. Rochester, NY 14650 (716) 724-1336	IBM	Not disclosed	To supply high-speed electro-photographic printer engines for a new IBM mainframe printer.
EG&G Energy Measurements 4S William St. Wellesley, MA 02181 (617) 237-S100	U.S. Department af Energy	$1.13 billion	To provide technical support far the department's undergraund nuclear-weapans test site in Nevado.
EG&G Energy Measurements 45 William St. Wellesley, MA 02181 (617) 237-S100	U.S. Department of Energy	$1 billian	Ta manage and aperate the department's Mound Plant, a research, develapment, and praductian facility in Miamisburg, Ohia.

AWARDED TO	AWARDED BY	AMOUNT	PURPOSE
Ericsson 100 Park Ave. New York, NY 10017 (212) 685-4030	Swedish Armed Forces, Materiel Administration	$16.9 million	To provide MX0 2000 digital switches for use at air bases in Sweden.
Ericsson 100 Park Ave. New York, NY 10017 (212) 685-4030	Telefonos de Mexico S.A.	$170 million	To supply digital and analog switches and equipment for the Mexican public telephone network.
Ericsson 100 Park Ave. New York, NY 10017 (212) 685-4030	Crowley Cellular Telecommunications	$2.8 million	To provide a $1.2-million cellular radio system for Binghamton, New York, and a $1.6-million cellular system for Huntsville, Alabama.
Ericsson 100 Park Ave. New York, NY 10017 (212) 685-4030	Santa Barbara Cellular Systems	$1.8 million	To provide cellular-radio-system equipment for Santa Barbara, California.
Fisher Controls International 8301 Cameron Rd. Austin, TX 78753 (512) 835-2190	Monsanto Chemical	$20 million	To supply and install instrumentation to support computer-integrated manufacturing.
GTE Communications Systems ELF Program, 77 A St. Needham, MA 02194 (617) 449-2000	U.S. Navy	$62 million	To produce, test, and supply submarine receivers for the Extremely Low Frequency (ELF) radio system.
ICF 9300 Lee Highway Fairfax, VA 22031 (703) 934-3000	U.S. Environmental Protection Agency, Office of Groundwater Protection	$21 million	To plan and implement programs related to protecting U.S. groundwater resources.
ICF 9300 Lee Highway Fairfax, VA 22031 (703) 934-3000	U.S. Army Toxic and Hazardous Materials Agency	$6.5 million	To investigate and perform feasibility studies of toxic and hazardous waste sites at U.S. military installations.
Litton 490 L'Enfant Plaza East, S.W. Washington, D.C. 20024 (202) 554-2570	U.S. Army	$8.7 million	To research ways to improve training in light infantry, land navigation, and weapon systems.
Planning Research 1500 Planning Research Dr. McLean, VA 22102 (703) 556-2749	U.S. Executive Office of the President	$15 million	To provide professional and management services, including software support.
Spire Patriots Park Bedford, MA 01730 (617) 275-6000	Rochester Gas and Electric	$29,000	To apply a new approach for monitoring the wear of labyrinth seals in steam-turbine systems, at the Beebee Generating Station in Rochester, New York.
Textron 2 Industrial Ave. Lowell, MA 01851 (617) 452-8961	NASA's Langley Research Center	$959,500	To develop small-diameter fibers for reinforcing titanium-based metal matrix composites at more than 1,500 degrees Fahrenheit.
Thorn Ericsson 100 Park Ave. New York, NY 10017 (212) 685-4030	British Telecom	$35 million	To provide AXE digital switches for British Telecom's local-switch replacement program, which affects 226,000 lines.
Voice Prints 31918 Airport Loop Dr. Costa Mesa, CA 92626 (714) 979-5666	Amway	$325,000	To provide a voice-activated order-entry system that uses Texas Instruments voice-recognition technology and Voice Prints software.

MERGERS

COMPANY	BUSINESS	COMPANY	BUSINESS	NEW NAME
Agfa-Gevaert Graphics 275 North St. Teterboro, NJ 07608 (201) 2B8-4100	Produces photographic chemicals for commercial printers and graphic artists	Compugraphic 200 Ballardvale St. Wilmington, MA 01B87 (617) 65B-5600	Oevelops and monufactures hardware and softwore for computerized typesetting	Compugraphic becomes o wholly-owned subsidiory af Agfo-Gevaert but retoins its name
Ecad 2455 Augustine Or. Santa Claro, CA 95054 (408) 727-0264	Makes computer-aided engineering and design software for creating integrated circuits	50A Systems 555 River Oaks Pkwy. San Jose, CA 95134 (40B) 943-1234	Oevelops softwore for designing integrated circuits	Ecad
Logica PLC 64 Newmon St. Londan, England W1A 4SE (441) 637-9111	Provides custom software and consulting services ta banks	Oata Architects 245 Winter St. Waltham, MA 02154 (617) 890-7730	Offers custom software ond services for the financial ond telecommunicatians industries	Oata Architects becomes o wholly-owned subsidiary of Logico but retoins its name

ACQUISITIONS

BUYER	BUSINESS	COMPANY ACQUIRED	BUSINESS	AMOUNT
Affiliated Publicatians 135 Morrissey Blvd. Boston, MA 02107 (617) 929-3300	Owns ond operates publishers including Globe Newspaper Co. and Billboord Publications	Xyquest 44 Manning Rd. Billerica, MA 01821 (617) 671-0888	Oevelaps and morkets word-processing software	$3 million (40 percent interest)
AGS Computers 1139 Spruce Or. Mountoinside, NJ 07092 (201) 654-4321	Provides computer outomation of telecommunicotion and computer systems	C3 460 Herndon Pkwy. Herndon, VA 22070 (703) 471-6000	Supplies computer systems to the federal government	$157.5 million (est.)
Alliant Computer Systems 42 Nagog Park Acton, MA 01720 (617) 263-9110	Oesigns ond manufactures 64-bit porollel processors	Roster Technologies 2 Robbins Rd. Westfard, MA 018B6 (617) 692-7900	Oesigns and builds color grophics terminols ond accelerators	$15 million (est.)
Apple Computer 20525 Morioni Ave. Cupertino, CA 95014 (408) 996-1010	Makes persanal computers, peripheral equipment, and software	Network Innovations 20863 Stevens Creek Blvd. Cupertino, CA 95014 (40B) 257-6800	Oevelops and morkets standard connectivity software for distributed computing systems	More than $10 million (est.)
AT&T 100 Southgate Parkway Morristown, NJ 07960 (201) 898-2000	Mokes communicotions equipment, computers, and saftware	Tridom 840 E. Fronklin Ct. Marietta, GA 30667 (404) 426-4261	Provides satellite-network equipment and services	$25-$50 million (est.)
Bell South 675 Peachtree St. N.E. Atlanta, GA 30375 (404) 420-8600	Provides regional telephane services	Mobile Communicatians Capital Towers Building Jackson, MS 39201 (601) 969-1200	Provides a network for mobile-phone, poging, ond answering services	$72 million
Electronic Oata Systems 7171 Forest Lone Oallas, TX 75230 (214) 468-1000	Installs and operates data-processing systems	MTech Box 152055 Irving, TX 75015 (214) 506-4000	Provides electronic-banking services and software to financial institutions	$281 million (80 percent interest)
General Automation Box 4883 Anaheim, CA 92B03 (714) 778-4800	Manufactures non-IBM-compatible microcomputers	Californio Business Systems 245 Fisher Costo Meso, CA 92626 (714) 641-8488	Oevelops and morkets software for rentol businesses	Not disclosed
General Signal High Ridge Park Stomford, CT 06904 (203) 357-8800	Makes electronic, telecammunicotions, factory-automotion, and railway equipment	GCA 209 Burlington Rd. Bedford, MA 01730 (617) 975-0000	Makes semiconductor-production and factory-outomation systems	$76 million

BUYER	BUSINESS	COMPANY ACQUIRED	BUSINESS	AMOUNT
IBM Old Orchard Rd. Armonk, NY 10504 (914) 765-1900	Makes computers, peripherals, and software	PocTel Spectrum Service div. 44 S. Broadway White Plains, NY 10601 (914) 686-1900	Provides a service that identifies breakdowns in communications networks	Not disclosed
QMS 1 Magnum Pass Mobile, AL 36618 (205) 633-4300	Builds laser printers, graphics processors, and electronic publishing equipment	Imagen 2650 San Tomas Expressway Santa Clara, CA 95051 (408) 986-9400	Develops image-processing technology; builds systems for publishing and printing	$17 million (est.)
Quality Technologies 108 Gilbert Menlo Park, CA 94025 (415) 493-1188	Makes electronic test equipment	Gen. Instrument's Optoelec. Div. 3400 Hillview Ave. Palo Alto, CA 94304 (415) 493-0400	Manufactures light-emitting-diode components and materials	$25 million (est.)
SBE 2400 Bisso Lane Concord, CA 94520 (415) 680-7722	Makes one-board microcomputers and process-control software	Alcyon 5010 Shoreham Place San Diego, CA 92122 (619) 587-1155	Develops real-time systems software; builds high-end microcomputers	Not disclosed
SPC Software Services 11225 North 28th Dr. Phoenix, AZ 85029 (213) 345-3542	Develops software systems for processing securities transactions	Precision Business Systems 61 Broadway New York, NY 10006 (212) 425-0200	Develops software for financial services, including electronic funds transfer and integrated banking	Not disclosed
Tandy 1800 One Tandy Center Fort Worth, TX 76102 (817) 390-3700	Manufactures and sells electronic products	Grid Systems Box 7535 Mountain View, CA 94039 (415) 961-4800	Makes portable microcomputers	$55 million (est.)

JOINT VENTURES

COMPANY	COMPANY	PURPOSE	CONTACT
Advanced Control Engineering	Solametrics	To design, market, and manufacture chemical control systems for the semiconductor industry.	Advanced Control 3070 Lawrence Expy. Santa Clara, CA 95051 (408) 730-4446
Amdahl	Sun Microsystems	To standardize the Unix operating system to make it easier for Sun workstations to work with Amdahl mainframes.	Amdahl 1250 E. Arques Ave. Sunnyvale, CA 94088 (408) 746-6076
AT&T	Cable & Wireless PLC and Telecommunications of Jamaica Ltd.	To establish an international digital telecommunications company in Jamaica called Jamaica Digiport International.	AT&T 1200 Mt. Kemble Ave. Basking Ridge, NJ 07920 (201) 953-7000
Imaging Technology	LSI Logic	To develop products combining LSI's image-processing integrated circuits and Imaging Technology's image-processing boards and subsystems.	Imaging Technology 600 W. Cummings Park Woburn, MA 01801 (617) 938-8444
MacroChem	Boston University	To develop a system for delivering drugs through the skin using electric currents.	MacroChem 21X Olympia Ave. Woburn, MA 01801 (617) 938-6510
Magnum Technology	Jasmine Digital	To establish a new company, Magnum Digital, in Hong Kong, to manufacture thin-film-sputtered disks.	Magnum Technology 5630-8 Kearny Mesa Rd. San Diego, CA 92111 (800) 663-4353
Plessey Semiconductors, North American group	Applied Micro Circuits	To develop emitter-coupled-logic gate arrays.	Plessey Semiconductors 9 Parker Irvine, CA 92718 (714) 472-0303

RESEARCH REPORTS

STUDY BY	TITLE	FORECAST	PRICE
Business Communications 25 Von Zont St. Norwolk, CT 06855 (203) 853-4266	Chemicols for the Semiconductor Industry (#C-028)	The market will increase ot on overoge onnuol rote of 8 percent to reoch $3.9 billion by 1997.	$1,750
Business Communicotions 25 Von Zont St. Norwolk, CT 06855 (203) 853-4266	ISDN ond Its Impoct On Customer-Premise Equipment (#G-109)	Annuol revenues will soor from the 1987 level of $10.6 billion to $16.9 billion by 1997.	$1,950
Business Technology Reseorch Box 81210 Wellesley Hills, MA 02181 (617) 237-3111	Drug Delivery Systems	By 1991, new systems for odministering medicotion will generate $5 billion in 1991.	$1,950
Business Technology Reseorch Box 81210 Wellesley Hills, MA 02181 (617) 237-3111	Monufocturing Vision Systems	Electronics monufocturers should become the primory vision-system morket, which will equol $4 billion by 1997.	$1,950
Electronic Trend Publications 12930 Soratogo Ave. Sorotogo, CA 95070 (408) 996-7416	Understonding Porollel-Processing Computers	This superminicomputer morket will grow to $12 billion in 1991 from its 1986 level of $4 billion.	$175
Frost & Sullivan 106 Fulton St. New York, NY 10038 (212) 233-1080	The Application-Specific Integrated-Circuit (ASIC) Morket in the U.S. (#A1773)	The merchont ASIC market will go from 1987's $2.4 billion to $5.2 billion by 1992; the coptive ASIC morket should expond from 1987's $660 million to $1.4 billion by 1992.	$2,100
Gartner Group Box 10212 Stomford, CT 06904 (203) 967-6848	1987 Comtec Report on Telephone Systems	AT&T continues to be the lorgest ployer in most telephone morkets, os others develop niche morkets. The telephone-systems market foces temporory saturotion.	$35,000
Input 1280 Villo St. Mountoin View, CA 94041 (415) 961-3300	U.S. Electronic Doto Interchonge (EDI) Federol Morkets, 1987-1992	Federol-government demond for EDI products ond services will increose from 1987's level of $97 million to $196 million in 1992, ot on onnuol rote of 15 percent.	$1,250
Mortin Simpson & Compony 150 Broodwoy New York, NY 10038 (212) 406-5200	Immunodiognostics in the Biotechnology Age	Analyzes monoclonol-ontibody technology ond offers survey results on common tests. Includes strotegic ond finonciol profiles of the top seven monufocturers.	$975
Micro Publishing Report 21150 Howthorne Blvd. Torronce, CA 90503 (213) 371-5787	The Outlook for Desktop-Publishing Networks	Revenues for future desktop-publishing progroms for IBM PCs ond Mocintoshes will grow from $56 million in 1988 to $206 million in 1991.	$995
Newton-Evons Reseorch 3220 Corporote Court Ellicott City, MD 21043 (301) 465-7316	Independent Softwore Brond Preferences ond Plonned Expenditures in Lorge Corporotions	Independent softwore componies now receive nearly 40 percent of o corporation's totol ollotment for softwore it does not develop itself.	$995
Prognos 1853 McCraren Rd. Highlond Pork, IL 60035 (312) 831-0136	Hozordous-Woste Incineration Study	Federol restrictions on londfills will promote the use of incineration. The report covers the types of hazordous woste, incinerator technology, plus politicol ond cost considerations.	$1,850
Robert S. First 707 Westchester Ave. White Ploins, NY 10604 (914) 949-4248	Biosensors in Health Core—Progress, Chollenges, ond Business Opportunities in the U.S., Europe, ond Jopon	Biosensors will have o major impoct on the heolth-core morket. Profiles componies developing biosensor products ond ossesses potentiol technicol ond morketing borriers.	$6,000

COMPANY INDEX

The following is a list of companies mentioned in this issue and the pages on which they appear. Companies in Marketwatch, the High Technology Business Leading 100, and Newsletter Digest are not included.

Hideaway Desk; Sonic Ruler

HEALTH

Pain-ending alternative

HOURS IN AN office chair or weekends in the garden can lead to chronic pain that may not respond to conventional non-prescription pain relievers. An alternative therapy for sore backs, arthritis, headaches, and other maladies is transcutaneous electrical nerve stimulation (TENS), which can be administered using the Codetron from Electronic Health Machines Inc.

TENS therapy zaps nerves with low-level electricity to relieve muscular pain, and represents an alternative to drugs for long-lasting relief. Conventional TENS devices stimulate nerves to mask pain in the brain. However, the Codetron stimulates the brain to release endorphins, serotonin, and cortizone, the body's own pain relievers. The box-shaped unit sends electrical impulses through six wires to small pads placed on the aching areas.

The $950 device sends random electrical impulses. Most other units emit regular pulses that a person's nervous system can grow accustomed to, rendering the treatment less effective, according to Electronic Health Machines.

A Codetron treatment lasts 20 to 30 minutes, and a person may need 10 or more treatments before relief begins. A drawback is the complicated control of the device.

A doctor must prescribe the use of TENS devices. Electronic Health Machines is based at 111 Martin Ross Ave., Downsview, Ontario, Canada, M3J 2M1. Phone (416) 661-3030.

—Elizabeth Aaron

The Codetron nerve stimulator attacks aches electronically.

OFFICE

Desk plays hide 'n seek

MAINTAINING a corporate image can be difficult with a desktop crammed with high-tech necessities: computer, keyboard, monitor, printer, modem. The Paperless Desk from Compudesk Inc. helps managers and executives clean up their act.

Visitors see an impressively uncluttered, conventional-looking desk. But with the touch of a button, the back of the Paperless Desk rises, exposing an array of compartments to hold computer equipment and items such as a radio, compact-disc player, and a set of small speakers. The transformation takes about 20 seconds.

Compudesk builds customized contemporary or traditional models from hardwood and veneers, and finishes them in mahogany, cherry, walnut, or oak. Prices range from $6,000 to $10,000, depending on the type of wood.

The company is located at 931 State Rd. 434, Altamonte Springs, FL 32714. Telephone (800) 426-4764; in Florida, dial (305) 862-9132.

—Kenan Woods

OFFICE

Tape measure has ears

AN ULTRASONIC device offers a high-tech alternative to traditional tape measures for insurance adjusters, realtors, and other professionals who need to gauge distances. The Accutape measuring device, designed and built by Measurement Specialties Inc., takes two seconds to measure distances of 2 to 33 feet and is accurate to within one tenth of a foot.

To use the Accutape, you point it at an object on the far side of the distance to be measured—the opposite wall in a room, for instance. At the push of a button, the device sends out an ultrasonic pulse, then measures the time it takes the sound wave to bounce off the distant surface and return to a sensor in the unit. The Accutape contains a microprocessor that uses this data to calculate the distance, which appears on a liquid-crystal display.

The $40 gadget weighs five ounces and is about as big as a pack of cigarettes.

Measurement Specialties is located at 1133 Route 23, Wayne, NJ 07470. Telephone (201) 633-0440. Stanley and International Consumer Brands also market the device under their own labels, as shown below.

—Jennifer Christensen

PHOTOGRAPHS BY STEVEN MARK NEEDHAM

Little box measures long distances.

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For full details, contact Mr. Gordon Thompson, Idaho Department of Commerce, Division of Economic Development, 700 West State Street, Boise, Idaho 83720. (208) 334-2470.

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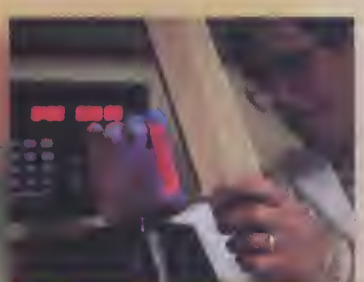

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